STATE OF TENNESSEE

DEPARTMENT OF
ENVIRONMENT AND CONSERVATION

Division of Water Pollution Control

Quality System
Standard Operating Procedure

for

CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

March 2004

This SOP is an intra-departmental document intended to govern the internal management of the Tennessee Department of Environment and Conservation and to meet requirements of the U.S. Environmental Protection Agency for a quality system. It is not intended to affect rights, privileges, or procedures available to the public.

DIVISION OF WATER POLLUTION CONTROL
QUALITY SYSTEMS STANDARD OPERATING PROCEDURES
FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING
OF SURFACE WATER

TABLE OF CONTENTS

DOCUMENT ADMINISTRATION

I. PROCEDURES

II. QUALITY CONTROL AND QUALITY ASSURANCE

III. REFERENCES

LIST OF TABLES

LIST OF FIGURES

IV. APPENDICES

DIVISION OF WATER POLLUTION CONTROL

QUALITY SYSTEM STANDARD OPERATING PROCEDURE FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

TITLE AND APPROVAL PAGE

DOCUMENT TITLE	Quality System Standard Operating Procedure for Chemical & Bacteriological Sampling of Surface Water
ORGANIZATION TITLE	Tennessee Department of Environment and Conservation Division of Water Pollution Control
ADDRESS	401 Church Street L&C Annex Nashville, TN 37243-1534
COMMISSIONER	Betsy Child
QUALITY ASSURANCE MANAGER	Cheryl Cole
ADDRESS	711 R.S. Gass Boulevard Nashville, TN 37243 (615) 687-7070 mailto:Cheryl.Cole@state.tn.us
DIVISION PROJECT MANAGER	Kimberly J. Sparks
ADDRESS	401 Church Street L&C Annex, 7th Floor Nashville, TN 37243-1534 (615) 532-0701 Kim.Sparks@state.tn.us
PLAN COVERAGE	General instructions for chemical and bacteriological sampling of surface waters and measurement of water parameters, flow and quality control in Tennessee.

APPROVALS AND CONCURRENCES

Approvals. This is to certify that we have reviewed this document and approve its contents.

Signature — Date: 3/1/2004

Cheryl Cole
TDEC-BOE Quality Assurance Manager

Signature — Date: 2/27/04

Paul E. Davis
Director
TN Division of Water Pollution Control

Signature — Date: 02/27/2004

Kimberly J. Sparks
Project Manager for Chemical and Bacteriological Sampling of Surface Water
TN Division of Water Pollution Control

Concurrences and Reviews. The following staff in the Division of Water Pollution Control participated in the planning and development of this project:

Kimberly J Sparks — Signature — 02/27/2004 — Date
Kimberly J. Sparks
Biologist III
TN Division of Water Pollution Control

Deborah D. Arnwine — Signature — 2-27-2004 — Date
Deborah Arnwine
Environmental Specialist V
TN Division of Water Pollution Control

Gregory M. Denton — Signature — 3/1/04 — Date
Gregory Denton
Environmental Program Manager I
TN Division of Water Pollution Control

Garland B. Wiggins II — Signature — 2/27/04 — Date
Garland Wiggins
Deputy Director
TN Division of Water Pollution Control

As a part of the internal review process, the following individuals reviewed this document.

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
Debbie Arnwine
Michael Atchley
Joellyn Brazile
Jonathon Burr
Bryan Carter
Linda Cartwright
Cheryl Cole
Robin Cooper
Greg Denton
Bobby DePriest
Natalie Harris
Lew Hoffman
Joe E. Holland
Jeff Horton
Kristen Howerton
Barbara Loudermilk
Ben Matthews
Dan Murray
Pat Patrick
John Price
Jimmy Smith
Terry Templeton
Andrew Tolley
Dick Urban
Garland Wiggins

Tennessee Department of Health
Environmental Laboratory
Craig Edwards
David Stucki

REVISIONS AND ANNUAL REVIEW PROCEDURE: QS-SOP FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

1. This document shall be reviewed annually to reconfirm the suitability and effectiveness of the program components described in this document.

2. A report of the evaluation of effectiveness of this document shall be developed at the time of review and submitted to appropriate stakeholders. Peer reviews shall be conducted, if necessary and appropriate. It shall be reconfirmed that the document is suitable and effective. It shall include, if necessary, clarification of roles and responsibilities, response to problem areas and acknowledgement of successes. Progress toward meeting TDEC–BOE mission, program goals and objectives shall be documented. Plans shall be made for the upcoming cycle and communicated to appropriate stakeholders.

3. The record identified as “Revisions” shall be used to document all changes.

4. A copy of any document revisions made during the year shall be sent to all appropriate stakeholders. A report shall be made to the Deputy Commissioner and Quality Assurance Manager of any changes that occur. Other stakeholders shall be notified, as appropriate and documented on the “Document Distribution” list.

NOTICE OF REVISION(S) RECORD

Date	Specific Section or Page	Revision Type (major or minor)	Revision Description

This revision(s) has been reviewed and approved. It becomes effective on: .

[Name]
Director
Division of Water Pollution Control

Date

[Name]
TDEC Quality Assurance Manager

Date

EVALUATION PROCEDURE: QS-SOP FOR CHEMICAL AND BACTERIOLOGICAL SAMPLING OF SURFACE WATER

As this document is used, needed changes or improvements will be apparent. Specific recommendations for improvements or changes are solicited as well as information concerning typographical or formatting errors.

1. Copy this page and complete all questions. Electronic versions are encouraged especially if comments are significant.

2. Send specific recommendations for improvements or changes, along with the following information, to:

   Kimberly J. Sparks
   TDEC, Division of Water Pollution Control
   7th Floor L&C Annex
   401 Church Street
   Nashville, TN 37243-1534
   (615) 532-0701
   e-mail address: Kim.Sparks@state.tn.us

Your Name	_____
Division, EAC or Section	_____
Address	_____
E-mail Address	_____
Telephone Number	_____
Document Effective Date	_____
Section(s) and Page Number(s) to which your comments apply	_____
Comments	_____
	_____
	_____
	_____
	_____
	_____
	_____
	_____
	_____
	_____

QS-SOP DOCUMENT DISTRIBUTION LIST

Copies of this document were distributed to the following individuals in TDEC and TDH. Additional copies were distributed to non-TDEC agencies and individuals upon request (including other state and federal agencies, consultants, universities etc.). An updated distribution list is maintained in the Planning and Standards Section.

The system for document distribution is described in TDEC-BOE Quality Manual, Chapters 5 and 10.

QS-SOP Recipient Name	Organization	Title	Telephone Number E-mail	Document Control Number
Fran Baker	WPC - CKEAC TDEC	Program Manager	931-432-7633 Fran.Baker@state.tn.us	
Gregory Denton	WPC – PAS TDEC	Program Manager	615-532-0699 Gregory.Denton@state.tn.us	
Dan Eagar	NRS – NCO TDEC	Program Manager	615-532-0708 Dan.Eagar@state.tn.us	
Jim Gibson	HL – LS TDH	Director	615-262-6303 Jim.Gibson@state.tn.us	
Natalie Harris	WPC – KEAC TDEC	Field Office Manager	865-594-5525 Natalie.Harris@state.tn.us	
John Hitz	LS – ELS TDH	Director	615-262-6300 John.Hitz@state.tn.us	
Joe E. Holland	WPC – NEAC TDEC	Field Office Manager	615-687-7020 Joey.Holland@state.tn.us	
Don Owens	WPC – KEAC TDEC	Program Manager	865-594-5527 Don.Owens@state.tn.us	
John Owsley	DOE-O TDEC	Director	865-481-0995 John.Owsley@state.tn.us	
Pat Patrick	WPC – JEAC TDEC	Field Office Manager	731-512-1301 Pat.Patrick@state.tn.us	
Saya Qualls	WPC – Permits TDEC	Program Manager	615-532-0652 Saya.Qualls@state.tn.us	
Paul Schmierbach	WPC – KEAC TDEC	Program Manager	865-594-5529 Paul.Schmierbach@state.tn.us	
Terry Templeton	WPC – MEAC TDEC	Field Office Manager	901-368-7959 Terry.Templeton@state.tn.us	
Andrew Tolley	WPC – JCEAC TDEC	Field Office Manager	423-854-5446 Andew.Tolley@state.tn.us	
Richard Urban	WPC – CHEAC TDEC	Field Office Manager	423-634-5702 Richard.Urban@state.tn.us	
Tim Wilder	WPC – CLEAC TDEC	Environmental Specialist	931-840-4170 Tim.Wilder@state.tn.us	
Sherry Wang	WPC – WSM TDEC	Program Manager	615-532-0656 Sherry.Wang@state.tn.us	

This document will be revised annually. Always use the most recent version.

PREFACE

The U.S. EPA requires that a centrally planned, directed and coordinated quality assurance and quality control program be applied to efforts supported by them through grants, contracts or other formalized agreements. This includes the implementation of a Quality Management Plan as written by the contract holder with Data Quality Objectives (DQOs) set in Quality Assurance Project Plans (QAPPs) for specific projects. The organization may elect to support portions of the QAPP through technical or administrative standard operating procedures (SOPs), as specified by the quality system. As a contract holder and through memoranda of agreement, the Tennessee Department of Environment and Conservation is required to maintain such a system.

This Quality System technical Standard Operating Procedure (QS-SOP) was prepared, reviewed, and distributed in accordance with TDEC's Quality Management Plan and other quality system documents in response to U.S. EPA's requirements for a Quality Management Program. QS-SOPs are integral parts of successful quality systems as they provide staff with the information to perform a job properly and facilitate consistency in the quality and integrity of the process.

This QS-SOP is specific to the Division of Water Pollution Control, is intended to assist the division in maintaining their quality control and quality assurance processes, and ensures compliance with government regulations. It provides specific operational direction for the division's Quality Assurance Project Plan for Chemical and Bacteriological Sampling of Surface Water.

I. PROCEDURES

I.A. Scope, Applicability and Regulatory Requirements

The purpose of this Quality Systems Standard Operating Procedure (QS-SOP) is to support the Quality Assurance Program. The document provides a consolidated reference document for use in training and orientation of employees. This guide will also be a reference tool for more experienced employees. It establishes an approach that can be recommended to sister agencies that monitor Tennessee water or stipulated to members of the regulated community given monitoring requirements in receiving waters. This SOP describes the chemical and bacteriological surface water collection process and delineates all steps in the process including water sample collection, quality control sample collection, documentation, water parameters and flow measurement. This SOP is only intended to describe routine conditions encountered during a surface water-sampling event.

The purpose of this SOP is not to supersede professional judgment, but rather is intended to insure that appropriate sampling methods and quality assurance procedures are employed. Discuss any deviations from the protocols outlines in this SOP with the in-house EAC QC officer for chemical and bacteriological sampling or the central office QC coordinator. Document any departure from this protocol.

Federal Statutory Authority

Federal Water Pollution Control Act (amended through P.L. 106-308, October 13,2000) as Amended by the Clean Water Act of 1977 enacted by Public Law 92-500, October 18, 1972, 86 Stat. 816; 33 U.S.C. 1251 et. seq.
Title III, Sec. 302: Water Quality Related Effluent Limitations
Title III, Sec. 303: Water Quality Standards and Implementation Plans
Title III, Sec. 304: Information and Guidelines
Title III, Sec. 305: Water Quality Inventory

Tennessee Statutory Authority

Tennessee Water Quality Control Act of 1977 (Acts 1971, ch. 164, § 1; 1977 ch. 366, § 1; T.C.A., § 70-324).

Tennessee Regulatory Authority

General Water Quality Criteria and the Antidegradation Statement: Rule 1200-4-3 (specifically 1200-4-3-.03, Criteria for Water Use and 1200-4-3-.06, Tennessee Antidegradation Statement)
Use Classifications for Surface Waters: Rule 1200-4-4.

I.B. Summary of Method

This document describes procedures approved by the Division of Water Pollution Control for collecting chemical and bacteriological samples of surface water. The objective of surface water sampling is to obtain a representative sample that does not deteriorate or become contaminated before it is analyzed. To verify the accuracy and representativeness of sample analyses, proper sample collection and preservation techniques, and appropriate quality control measures must be followed.

Protocols are explained for collecting a representative sample using the appropriate sample container, preservative, and collection techniques for both wadeable and non-wadeable waters. Protocols are specified for the most common sample types including bacteriological, routine, nutrient, metal, NPDES extractables and volatiles and pesticides/PCBs. General protocols are also described for the specifications and accurate use of various devices associated with chemical and bacteriological surveys including multi-parameter probes, continuous monitoring probes, automatic samplers, and flow meters. To ensure the integrity of all samples, protocols concerning sample custody, chain of custody, and quality control samples are also included in this document.

I.C. Definitions and Acronyms

Ambient Monitoring: Routine sampling and evaluation of receiving waters not necessarily associated with periodic disturbance.

Bias: Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Composite Sample: Composite samples can be time or flow proportional. Time integrated composite samples are collected over time, either by continuous sampling or mixing discrete samples. Flow proportional composite samples are composed of a number of samples sized relative to flow. Composite samples may also be combined manually by collecting grab samples at various intervals in a waterbody.

Convex meniscus: The curved upper surface of a liquid column that is concave when the containing walls are wetted by the liquid.

Ecological Subregion (or subecoregion): A smaller area that has been delineated within an ecoregion that has even more homogenous characteristics than does the original ecoregion. There are 25 (Level IV) ecological subregions in Tennessee.

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables. There are eight (Level III) ecoregions in Tennessee.

Ecoregion Reference: Least impacted waters within an ecoregion that have been monitored to establish a baseline to which alterations of other waters can be compared.

Grab Sample: Grab samples consist of either a single discreet sample or individual samples collected over a period of time not to exceed 15 minutes.

Kemmerer: A type of discrete depth sampler. A Kemmerer is composed of a cylinder with stoppers on each end that can be closed remotely with the use of a weighted messenger.

Lentic waters: Contained waters with restricted flows including lakes, ponds, wetlands and reservoirs.

Lotic waters: Flowing waters including rivers and streams.

Definitions Continued

Organic-free Reagent Grade Water (Type I): Potable water that has been treated by passing through a standard deionizing resin column and filtered through activated carbon. The water must meet analyte free water criteria and have no detectable metals, inorganic compounds, pesticides, herbicides, or extractable or volatile organic compounds. This water may be obtained from the TDH Environmental Central or Branch Laboratories. Always use as fresh as possible organic-free reagent grade water.

Quality Assurance (QA): Includes quality control functions and involves a totally integrated program for insuring the reliability of monitoring and measurement data; the process of management review and oversight at the planning, implementation and completion stages of date collection activities. Its goal is to assure the data provided are of high quality and scientifically defensible.

Quality Control (QC): Refers to routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process; focuses on detailed technical activities needed to achieve data of the quality specified by data quality objectives. QC is implemented at the field or bench level.

Reference Database: Biological, chemical, physical, and bacteriological data from ecoregion reference sites.

Recommend: Advise as the best course of action. Synonyms: optional, may, should.

Require: Obligatory or necessary. Synonyms: must or shall.

Split Sample: A sample that has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

Thalweg: A line representing the greatest surface flow and deepest part of a channel.

Trace Metals: Low-level metal analyses requiring ultra-clean sample collection and laboratory analyses generally reported in the low parts per trillion range.

Wadeable: Rivers and steams less than 4 feet deep unless there is a dangerous current.

Watershed: The area that drains to a particular body of water or common point.

Acronyms

ASTM	American Society of Testing and Materials
ATCC	American Type Culture Collection
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CFS	Cubic Feet/Second
D.O.	Dissolved Oxygen
DQOs	Data Quality Objectives
EAC	Environmental Assistance Center
ES	Environmental Specialist
EPA	Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbons
Ft/S	Feet per Second
GPS	Global Positioning System
GRO	Gasoline Range Organics
LDB	Left Descending Bank
LEW	Left Edge of Water
LIMS	Laboratory Information Management System
MDL	Minimum Detection Limit
MPN	Most Probable Number
MSDS	Material Safety Data Sheet
N	Questionable Data
NCR	No Carbon Required
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAS	Planning and Standards Section
PCBs	Polychlorinated Biphenyls
PFD	Personnel Floatation Device
QAPPs	Quality Assurance Project Plans
QA/QC	Quality Assurance/Quality Control
RDB	Right Descending Bank
REW	Right Edge of Water
SOP	Standard Operating Procedure
TAL	Target Analyte List
TCLP	Total Characteristic Leeching Procedure
TDEC	Tennessee Department of Environment and Conservation
TDH	Tennessee Department of Health
TMDL	Total Maximum Daily Loading
TOC	Total Organic Carbon
TOPO	Topographic Map
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
WMS	Watershed Management Section
WPC	Water Pollution Control

I.D. Health and Safety Warnings

(Adopted from Klemm et al., 1990)

1. Know how to swim.

2. Always wear a belt with chest waders to prevent them from filling with water in case of a fall. If it is necessary to wade in high velocity and high flow streams it is advisable to wear a life jacket.

3. Follow Tennessee boating laws and regulation. Information is available through the Tennessee Wildlife Resources Agency (TWRA). Life jackets are required when operating a boat.

4. Be vigilant in streams, especially turbid streams to avoid broken glass, beaver traps or other sharp objects that may lie out of sight at the bottom of streams.

5. Keep first aid supplies in the EAC office and in the field at all times. Training in basic first aid and cardio-pulmonary resuscitation is strongly recommended.

6. Any person allergic to bee stings or other insect bites should have needed medications in the event of an allergic reaction and instruct others in the party on how to use the allergy kit.

7. Always handle acid preservatives under a properly installed and operating fume hood. Check to be certain the fume hood is functioning properly. Always wear personnel protective equipment (gloves, safety glasses, and lab coat) when handling preservatives. Be aware of location and how use eyewash and shower stations.

8. It is recommended that communication equipment be taken in the field in case of an emergency.

9. Carry a list of emergency contact numbers for the sample area. Know location of hospitals and law enforcement stations in the area.

10. Consider all surface waters a potential health hazards due to toxic substances or pathogens. Minimize exposure as much as possible and avoid splashing. No eating, drinking, smoking, applying cosmetics or handling contact lens while collecting samples. Clean exposed body parts (face, hands, and arms) immediately after contact with these waters. Carry phosphate-free soap and an adequate supply of clean water, disinfectant wipes, or waterless sanitizer for this purpose. At earliest convenience, thoroughly wash exposed areas with soap and water.

11. If working in water known or suspected to contain human wastes, EPA recommends immunization against tetanus, hepatitis, and typhoid fever (Table 1). Unfortunately, TDH has reviewed studies that indicate a minuscule risk of contracting Hepatitis without coming in direct contact with an infected person and do not believe vaccinations are warranted. As recently as August 2002, the TDH has denied WPC request for such vaccinations. However, this does not preclude employees from contacting their physician and requesting vaccinations they believe are appropriate.

    Table 1: EPA Recommended Vaccinations

Vaccination	**No. of shots**	**Interval**	**Booster**
Hepatitis B	3	0, 1, 6 months	NA
Tetanus	1	NA	10 years
Polio	1, if childhood series completed	NA	20 years
Typhoid	2	1 month	3 years

12. Try to avoid working alone in the field. If working alone, make sure your supervisor or their designee knows where you are and check in periodically.

13. Material Safety Data Sheets (MSDS) are available for all preservatives and other hazardous chemicals. Everyone working with these agents or handling preserved bottles must be familiar with the location and contents of the MSDS. Notify supervisor if MSDS sheets cannot be located.

14. Be aware of potentially volatile situations. If possible, obtain permission from landowners before crossing private property. Have business cards available to leave at residences when appropriate.

15. It is recommended that powder-free gloves be worn when handling samples. In waters known or suspected to have high pathogen levels the sampler may choose to wear shoulder length gloves. Always wear gloves when analyzing bacteriological samples. Any person allergic to latex may wear nitrile or other appropriate powder-free gloves.

16. Check to make sure lids are tightly fastened and pre-preserved bottles are stored in an upright position.

17. In very hot weather, store pre-preserved bottles on ice to avoid acid vaporization and a potentially hazardous situation when opening a swollen bottle. Pressurized bottles can spray acid when opened, could cause acid burns on eyes and exposed skin.

18. When traveling in a state vehicle always wear a seat belt and follow all Tennessee Department of Safety and Motor Vehicle Management rules.

19. In the event of a life-threatening emergency, go to the nearest hospital. Call for emergency assistance if moving the injured person is likely to inflict further injury. If a non-life threatening injury occurs on the job, seek medical assistance from the authorized state worker's compensation network. A current list of providers may be found on the State Treasurer's homepage under Workers Compensation, Provider Directory at www.treasury.state.tn.us. Always complete and file an accident report if medical assistance is provided for a work related injury.

20. If water conditions necessitate that water samples are collected from a bridge, appropriate safety precautions must be employed to ensure the safety of personnel as well as drivers. OSHA's *Manual on Uniform Traffic Control Devices* (1993) provides safety instructions for work on and near roadways. Since chemical sampling events occupy a location for less than one hour (Short Duration-Work), OSHA allows for simplified traffic control procedures. Specialized safety equipment must be used to warn oncoming traffic of staff present on the bridge.

    - Orange safety vest for every member of the sampling team
    - At least five orange traffic cones or traffic warning triangles
    - Magnetic amber strobe light (and spare batteries)

    Use extreme caution when working on the bridge and around traffic. All personnel involved in sampling from the bridge must wear an orange safety vest while working from the bridge. If possible, park the vehicle out of the lane of traffic before crossing the bridge on the upstream side. Set the parking break, turn on the emergency lights and place the magnetic strobe light (turned on) on the roof of the vehicle where it is most visible to on-coming traffic.

    Place at least 4 orange traffic cones in a diagonal line from outside edge of the shoulder behind the vehicle toward the white line for the lane of traffic. Place the final cone on the bridge at the beginning of the work area. Avoid inhibiting the flow of traffic. Spend as little time on the bridge as possible. To avoid falling off the bridge, do not lean off the bridge or climb over railings.

I.E. Cautions

1. Avoid sampling bias by following the procedures outlined in this document. Document any deviations from this SOP.

2. Avoid cross contamination of samples. Always use new collection bottles. It is recommended that samples be placed in colorless plastic zip-type bags to avoid cross contamination in the cooler.

3. Use the standardized station ID naming protocol for all surface water samples (Protocol B). Continue to use established naming protocols for NPDES samples and ecoregion reference sites. Make sure the station ID is included on all paperwork and tags associated with the sample.

4. To avoid errors, calibrate all meters at the beginning of each day (unless overnight travel is required). Perform a drift check at the end of each day (or on return to office if overnight sampling). If the meter calibration is off by more than 0.2 units for pH, D.O. or temperature or by more than 10% for conductivity, precede all readings between the initial calibration and the drift check with an N (questionable data) on the stream survey sheet and on any Chemical Request Forms turned in at the TDH Environmental lab. If sample request forms have already been submitted, notify the Planning and Standards Section of questionable readings in writing (e-mail or fax).

5. Record all time in a 24-hour (military) clock format.

6. Write all dates in mm/dd/yy or mm/dd/yyyy format. (For example, March 2, 2003 would be 03/02/03 or 03/02/2003.)

7. Record all distance measurements in meters, with the exception of flow. Flow is measured in cubic feet per second (cfs). If instrument or tape measure is in different units, record the actual readings and convert to appropriate units before reporting results.

8. Set all meters to measure temperature in degrees centigrade (C^o). Record all temperature readings in degrees centigrade.

9. If an error is made in any documentation, draw a single line through the error and write the correction above. Date and initial the correction.

I.F. Interferences

1. Document all deviations from protocol.

2. Unless the study design requires flood or post-flood sampling, avoid sampling in flooded conditions or immediately after a flood.

3. Avoid sampling streams reduced to isolated pools unless deemed necessary for study objectives.

4. Flag dissolved oxygen, pH, temperature and conductivity readings with an N (questionable data) if post-trip drift checks show meter calibrations to be off by more than 0.2 units (or 10% for conductivity). All readings taken between initial calibration and drift check should be flagged.

5. Properly clean any reusable sample contact equipment such as Nalgene® bucket, Teflon Kemmerer or bailer, or composite samplers between uses. See Section I.H and I.I, Protocol E for cleaning procedures for sampling equipment.

6. Do not smoke while collecting samples.

7. It is recommended that powder-free gloves be worn while sampling. Powder-free nitrile or latex gloves must be worn when collecting nutrient, trace metal, low-level mercury, or organic samples.

8. Before collecting nutrient samples, wash hands with phosphate-free soap.

9. When collecting samples to be analyzed for trace metals, low-level mercury, or organics avoid wearing lotions, insecticides, sunscreens, or other chemicals that could potentially contaminate samples.

I.G. Personnel Qualifications and Training

Tennessee Civil Service Titles: Biologist, Environmental Specialist, Environmental Protection Specialist, Environmental Program Manager, Environmental Field Office Manager, Chemist or trained co-op/intern. For the purpose of this report, all position titles will be referred to as sampler or staff.

Minimum Education Requirements: B.S. in any science, engineering, or B.S. candidate under the supervision of experienced staff.

Minimum experience: There is no substitute for field experience. It is recommended that all staff have at least 6 months of field experience before selecting sampling sites. For on the job training, new employees should accompany experienced staff for as many different studies and sampling situations as possible. During this training period, the new employees are encouraged to perform all tasks involved in sample collection under the supervision of an experienced staff member.

Quality Team Members are to be selected by EAC WPC managers to oversee quality control and training and help ensure the protocols outlined in this document are properly followed. Quality Team Leader is a centralized chemical and bacteriological QC coordinator. Quality Team Leader and Members should be experienced water quality personnel who have been trained in water quality sampling and quality control (Section II.A).

Expertise: Use and calibration of standard water quality monitoring meters (DO, pH, conductivity, and temperature meters), flow meters and wading rods, subsurface sampling devices, discrete depth sampling devices (Kemmerer and peristaltic pump), composite samplers, GPS, and boats.

Training:

Protocols outlined in this SOP

- Assigning Station identification numbers
- Sample collection procedures, equipment cleaning, and use for wadeable and non-wadeable surface water collections
- Cleaning, maintenance, and use of automatic samplers
- Completion of sample identification tags, sample request forms and chain-of-custody
- THD laboratory requirements for sample submission
- Calibration and maintenance of instantaneous and continuous water parameter probes
- Calibration and maintenance of flow meters
- Use of map wheels, topographic maps, GPS units, cameras and other equipment
- Bacteriological analyses

Quality System Requirements
Quality Assurance Project Plan
Boat Operation
Health and Safety

I.H. Equipment and Supplies

Prior to any sampling trip, gather and inspect all necessary gear. Replace or repair any damaged equipment. Order sample bottles at least one week before they are needed (Appendix A). Calibrate all meters the morning of the sampling trip. Upon return from a trip, take care of any equipment repairs or replacements immediately. Necessary equipment will vary per project, but the following is a standardized list.

1. General Field Equipment

- Waders
- External sample tags
- Sample request forms
- Field Flow Sheet or field book
- Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads
- Tennessee Atlas and Gazetteer
- GPS unit for recording latitude and longitude in decimal degrees at new stations
- Cell Phone or other communication device (recommended)
- Calibrated dissolved oxygen meter
- Calibrated pH meter
- Calibrated conductivity meter
- Calibrated temperature meter or thermometer in ^{o}C
- Repair kit for water parameter meters (DO replacement membrane for multi-day trips)
- Calibrated flow meter, wading rod (10^{th} of feet markings), and sensor cable
- Measuring or surveyors tape (10^{th} of feet markings) and rope long enough to span the river or stream
- Stakes, clamps, and hammer
- Flow meter manual and screwdriver
- Spare batteries for all meters
- Waterproof pens (Sharpies®), pencils and black ballpoint ink pens (not roller-ball)
- Flashlights in case detained after dark
- Duct tape for emergency repairs
- First aid kit
- Watch
- Map wheel (for calculating stream miles)
- Sample bottles + 10% QC bottles
- 1 gallon plastic zip-type bags (recommended)
- Powder-free latex or nitrile gloves (Required for nutrient sampling)
- Shoulder length powder-free gloves (if collecting trace metals or mercury)
- Ice stored in coolers (ice may be placed in plastic bags for easier handling)
- Clean coolers
- Temperature blank bottle (1/cooler)
- Custody seals
- Camera for documenting potential pollution sources and waterbody conditions

a. Additional Items Needed for Non-Wadeable Sites

- ☐ Bacteriological sampling: swing sampler or other appropriate bottle holder or sterile sampling device
- ☐ Inorganic chemical sampling: Teflon® or High Density Polyethylene (Nalgene®) bucket attached to a rope, Teflon® Kemmerer, bailer, or peristaltic pump
- ☐ Organic chemical sampling: stainless steel bucket (attached to a rope), Kemmerer, or bailer

If Using a Boat

- ☐ Boat with appropriate safety equipment, paddles, and PFDs

b. Additional Items Needed for Field Cleaning Equipment

- ☐ Phosphate-free laboratory-grade detergent
- ☐ Tap water stored in a clean covered tank, or squeeze bottle
- ☐ Deionized water stored in a clean covered tank or squeeze bottle

c. Additional Items Needed for Diurnal Monitoring

- ☐ Continuous monitoring probe
- ☐ Sensor cable
- ☐ Laptop computer programmed for the continuous monitoring multi-probe
- ☐ Field manual for the probe and software
- ☐ Stainless steel cable or chain
- ☐ Crimps
- ☐ Crimp and wire cutter pliers
- ☐ Nylon cable
- ☐ Appropriate anchoring and/or flotation device such as:
  - Rebar and hammer (firm substrate)
  - Wooden board (soft sand/silt substrate)
  - Concrete block (soft sand/silt substrate)
  - Float with probe holder to suspend the probe in the water column and a weight to hold it in place (deeper waters)

d. Additional Items Needed for Automatic Sampling

- ☐ Automatic sampler
- ☐ New Silastic® or equal tubing
- ☐ New Teflon® or Tygron® or equal tubing
- ☐ Clamps and/or electrical ties
- ☐ Spare batteries
- ☐ Ice

2. Bottles Acquisition and Preparations

At least one week prior to needing sample bottles for routine scheduled sampling place a bottle order (Appendix A) with the appropriate TDH Environmental Lab and notify the environmental and microbiological sample coordinators of when samples will be arriving (Table 2). Remember to include an adequate number of bottles for quality assurance testing of at least 10% of planned samples. TDH Environmental Laboratory has requested, "all samples submitted for analysis should be properly collected in bottles furnished and prepared by the Environmental Laboratories" (Tennessee Department of Health, 2001).

Be certain to collect the correct amount of sample for the lab to perform the appropriate analyses and the QC required by EPA. When picking up a bottle order, make sure the correct numbers of bottles are present and the lids on the pre-preserved bottles are tight to avoid preservative leakage, and possible acid burns. Always keep numerous spare bottles on hand for unscheduled complaint and emergency sampling. According to TDH laboratory, pre-preserved sampling containers may be stored for up to one year.

Note: If using another TDEC contract laboratory, contact the specific lab about obtaining bottles. Make sure that minimum required detection limits (Appendix B) will be meet and results will be sent to PAS.

Table 2: TDH Environmental Laboratory Contact Information

Nashville Central Laboratory 630 Hart Lane Nashville, TN 37247	Knoxville Regional Laboratory 1522 Cherokee Trail Knoxville, TN 37920	Jackson Regional Laboratory 295 Summar Dr. Jackson, TN 38301
Environmental Sample Coordinator: (615) 262-6342	Sample Coordinator: (865) 549-5279	Sample Coordinator: (731) 426-0685
Microbiological Sample Coordinator: (615) 262-6371		
After Hours Emergency Number: (615) 262-6300		

Contact the laboratory if samples cannot be delivered during normal hours of operation. If holding times are not an issue it may be best to secure the samples in a locked area in the EAC and deliver them to the laboratory the next day. It also may be possible to arrange for someone at the laboratory to receive the sample after hours. The final and least desirable option for after hour delivery is to have the security guard sign the chain-of-custody and secure the samples. The branch labs do not have security guards on duty so arrangements must be made ahead of time.

a. Sample Containers

(1). Bacteriological Collection Bottles

Collect bacteriological samples in sterile polypropylene screw-cap bottles pre-preserved with sodium thiosulfate and EDTA. These bottles may be obtained from TDH Environmental Laboratory or other TDEC contract laboratories. Most EAC offices are not equipped to properly prepare bacteriological sample containers.

Bacteriological bottles obtained from TDH Laboratory should minimally be labeled with a preparation date. Some laboratories also label bottles with an expiration date. Bacteriological bottles have a one-year shelf life from the date of preparation. Do not use expired bottles. To ensure an adequate volume of water is available for analyses, collect two 250-milliliters bottles for each sample. The two bottles are considered one sample and should be labeled with the same collection time.

(2). Inorganic Collection Bottles

Collect inorganic samples in the proper sample bottle with the appropriate preservative (Table 3). It is highly recommended that appropriately pre-preserved inorganic sample bottles be obtained from TDH Environmental Laboratory or other TDEC contract laboratories. Pre-preserved sample containers may be stored and used for one year. Only use pre-cleaned single use plastic bottles for routine, nutrient, metal, mercury, cyanide, boron, TCLP, and TOC sampling. Oil and grease, phenols, sulfides, and flash point samples are collected in properly cleaned (Section I.H) glass bottles.

See Protocol C for complete instructions on collection of inorganic samples. Special precautions are given for the collection of trace metal and low-level mercury samples. Protocols D, E, and F specify collection techniques for wadeable and non-wadeable waterbodies.

(3). Organic Collection Bottles

The most commonly requested organic analyses are NPDES extractable and volatiles, and pesticides/PCBs (Table 4). All organic samples are collected into properly cleaned amber bottles or vials. See Protocol C for complete instructions on collection of volatile samples. If analyses other than those listed here are needed, contact the organic section of TDH Environmental Laboratory or other TDEC contract laboratory for the appropriate sample container and sampling method.

Table 3: Inorganic Sample Bottles and Preservatives

Sample Type	**Bottle Type**	**Preservative**
Routine	1 liter or 1 gallon plastic	None
Nutrient	500 mL plastic	1 mL sulfuric acid (H_2SO_4) (Reagent Grade)
Metals	1 liter plastic	5 mL 70% nitric acid (HNO_3) (Trace Metal Grade)
Mercury	500 mL plastic	2.5 mL 70% nitric acid (HNO_3) (Trace Metal Grade)
Cyanide	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide ($NaOH_9$) at collection. 0.6 g ascorbic acid ($C_6H_8O_6$) if KI paper indicates chlorine.
Oil & Grease	1 liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4) (Reagent Grade)
Phenols, total	1 liter glass, amber with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4) (Reagent Grade)
Sulfide	500 mL glass	2 mL zinc acetate (ZnAc) in the lab. 5 mL 50% sodium hydroxide (NaOH) in field.
Boron	125 mL plastic	0.75 mL hydrochloric acid (HCl) (Reagent Grade)
Flash Point (Ignitability)	16-ounce glass jar with Teflon® lined lid.	None
Toxicity Characteristic Leaching Procedure (TCLP)	16-ounce glass jar	None
Total Organic Carbon (TOC)	125 mL plastic	0.25 mL sulfuric acid (H_2SO_4) (Reagent Grade)

Table 4: Organic Sample Bottles and Preservatives

Test	Container	Preservative
Base/Neutral/Acids Extractables		
NPDES Extractables	One (1) - 1-gallon amber bottle, acetone-rinsed, with Teflon®-lined cap	None
Pesticides/PCBs		
Target Analyte List (TAL) Extractables		
Nitrobodies (suspected explosives)		
Semivolatiles		
Volatiles and Petroleum Hydrocarbons		
NPDES Volatiles	Four (4) - 40-mL amber vials with Teflon®-lined septa caps, no headspace	1:1 Hydrochloric Acid (HCl) (Reagent Grade)
Target Analyte List (TAL) Volatiles		
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)	Five (5) – 40-mL amber vials with Teflon® lined septa caps, no headspace	1:1 Hydrochloric Acid (HCl) (Reagent Grade)
Gasoline Range Organics (GRO)		
Extractable Petroleum Hydrocarbons (EPH)	One (1) – 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl) (Reagent Grade)

b. Bottle Preparation

Always keep a few spare bottles on hand for emergency or unscheduled sampling. Pre-preserved sample containers may be stored up to one year. In the event of an emergency, if it is not possible to obtain bottles from the TDH Environmental Laboratory or other TDEC contract laboratories, they may be pre-preserved in the EAC lab. To avoid bottle contamination and personal injury, conform to the following procedure exactly. For specialized samples not listed here contact TDH Environmental Laboratory (Table 2) or other contract TDEC laboratories.

The unpreserved bottles purchased by TDH Environmental Laboratory are certified as "Contaminant Free Sample Containers". Each box of bottles comes with a Certificate of Analysis from the distributor. Therefore, do not clean or rinse the bottles before they are preserved or used.

Personal protective equipment must be worn to protect personnel from injury and the sample container from contamination. Wear safety glasses, a clean lab coat or apron, and powder-free latex or nitrile gloves whenever prepping sample bottles. Dispense acids into sample bottles under a properly functioning fume hood.

Use trace metal grade acids for metal and mercury bottle preservation. Use reagent grade acids for all other bottle preservation. Have acid blanks analyzed on every new bottle of acid purchased. MSDS sheets must be accessible for all acids or chemicals used in the EACs. Use properly cleaned (Section I.H) volumetric pipettes or automatic dispensers to dispense acids. Always use a bulb for pipetting, never mouth pipette. Store acids with compatible acids in their original labeled container in an enclosed cabinet used only for the storage of acids.

(1). Inorganic Bottle Preparation

Inorganic samples require the proper sample bottle (Table 3). Use only single use plastic bottles for routine, nutrient, metal, mercury, cyanide, boron, TCLP, and TOC sampling. Collect oil and grease, phenols, sulfides, and flash point samples in glass bottles that have been properly cleaned (Section I.H).

If preparing trace metal or low-level mercury sample collection bottles, a few additional precautions are required. It cannot be overemphasized how easily bottles can be contaminated. Most metals are measured in parts-per-billion (ug/l) or parts-per-trillion range. It has been proven that even exhaling on a sample if you have mercury amalgam fillings can contaminate the sample (USEPA, 1996, p. 4). Do not exhale on the sample bottle while preservative is being added for trace metal analyses.

After the preservative has been added to trace metal or low level mercury sample containers, replace the lid tightly and place each sample container in two zip-type colorless bags. Double bagging reduces the likelihood of the trace metal or low-level mercury container being contaminated by the environment or cross-contaminated during sampling or transport.

(2). Organic Bottle Preparation

Organic samples require the proper sample bottle(s) with the appropriate preservative. Organic sample containers are amber glass bottles that have been properly cleaned (Section I.H) followed by a final acetone rinse. All bottle or vial lids require Teflon® lined caps. See Table 4 for bottle and preservative requirements for various organic analyses.

3. Equipment Cleaning

a. Wader Cleaning Procedure

Rinse mud and debris from waders, between sampling sites to avoid cross-contamination. Mud may be rinsed from waders in creek or river before leaving the site.

b. Cooler Cleaning Procedure

To avoid cross-contamination between samples, clean all sample storage coolers with hot phosphate-free laboratory grade soapy water and thoroughly rinse with hot tap water between uses. Allow coolers to air dry and store in a clean area with lids closed. If coolers will be reused immediately, they do not need to be air dried after being washed and rinsed.

c. Water Parameter Bucket Cleaning Procedure

If a bucket will only be used for the measurement of water parameters, rinse it twice with surface water from the site before the water parameter sample is collected. When the bucket becomes visibly dirty, muddy, or oily, clean the bucket using the following sample equipment cleaning procedure.

d. EAC Lab Cleaning Procedure for Sampling Equipment

Clean all reusable equipment that comes in direct contact with sample water, such as Kemmerer, properly constructed sample bucket (Protocol F), or automatic sampler, between uses. It is preferable to arrange the sampling schedule so the equipment can be cleaned in the controlled environment of the EAC lab. If it is not possible to return to the EAC between sampling stations, the field cleaning procedure in Protocol E must be followed. Document any deviation from this procedure.

Cleaning procedure for sampling equipment:

(1). Soap Wash – Wash the equipment with a phosphate-free laboratory detergent, such as Alconox® or Sparkleen® and hot tap water. Use a clean scrub pad to remove any surface film or particulate matter. Store the soap in a clean container and pour directly from the container.

(2). Tap Water Rinse – Rinse the equipment thoroughly with hot tap water.

(3). Deionized Water Rinse – Rinse equipment at least twice with deionized water using either a squeeze bottle or the outlet hose from the deionizing system. If the sampling equipment is being cleaned for the collection of organic samples, the rinse water must be organic free reagent grade water and dispensed from a Teflon® squeeze bottle or a Teflon® outlet hose.

(4). Air Dry – Allow opened equipment to air dry on a clean surface before storage in a clean area.

e. Lab Cleaning Procedure for Glassware

Clean all glassware, such as pipettes, glass sample containers or any piece of equipment that will directly or indirectly contact sample water or preservative, between uses. Document any deviation from this procedure. Provide MSDS safety sheets for all solvents and acids used in this procedure. To avoid equipment contamination and personal injury, wear personal protective gear when cleaning sample contact equipment. Wear safety glasses, powder-free latex or nitrile gloves, and a clean lab coat or neoprene apron while cleaning the equipment. Do not eat, drink, smoke or have any hand to mouth contact while cleaning the equipment. Conduct all solvent rinses under a fume hood and never in a closed room.

Cleaning Procedure for Glassware and Glass Bottles:

(1). Soap Wash – Wash the equipment with a phosphate-free laboratory detergent such as Alconox® or Sparkleen® and hot tap water. Use a clean scrub pad to remove any surface film or particulate matter. Store the soap in a clean container and pour directly from the container.

(2). Tap Water Rinse – Rinse the glassware thoroughly with hot tap water.

(3). Nitric Acid Solution (10%) – Rinse glassware using a plastic squeeze bottle with a mixture of 10% nitric acid and 90% deionized water. Store Nitric Acid in its original labeled container until use. A 10% Hydrochloric Acid (HCl) rinse should be used for glassware or equipment intended for nutrient analyses. If a different acid rinse is used, document the acid used.

(4). Deionized Water Rinse – Rinse glassware thoroughly with deionized water using either a squeeze bottle or the outlet hose from the deionizing system. If the sampling equipment is being cleaned for the collection of organic samples, the rinse water must be organic free reagent grade water and the dispenser a Teflon® squeeze bottle or a Teflon® outlet hose.

(5). Solvent Rinse – Pesticide-grade isopropanol is the preferred final rinse of glassware. Store isopropanol in its original container until use and dispense using a Teflon® squeeze bottle. The final rinse for organic glassware is acetone. Acetone is a likely source of contamination if it is not allowed to completely evaporate. If acetone is used as a solvent rinse, it must be allowed to completely air dry before glassware is used. Document the solvent used if anything besides pesticide-grade isopropanol is the final rinse.

(6). Air Dry – Allow equipment to air dry on a clean surface and store glassware in a clean area.

I.I. Procedures

Protocol A - Selection of Sample Type and Site Location

Sampler
Central Office Coordinator

1. Sample Analyses Selection

The majority of samples are used for multiple purposes, regardless of the primary sampling objective. For example, TMDL samples will also be used for assessments, criteria development and ecoregion calibration. Therefore, all samples must have the same confidence in the accuracy of the sample quality and analyses. The study objective will determine what parameters need to be analyzed from a given sample. The parameters in turn determine the types of samples that need to be collected (Appendix B). Table 5 provides information on bottle types needed for the most common monitoring activities.

Consult WPC's Annual Water Quality Monitoring and Planning Workplan for specific details on planned sampling objectives. Samples collected for different purposes will have different sampling needs. Table 6 provides information on sample needs for some routine sampling activities.

a. Ecoregion samples require specific analyses.

b. Waters on the 303(d) List must minimally be sampled every watershed cycle, for the cause that they were placed on the 303(d).

c. Consult the Monitoring to Support TMDL Development protocol (Appendix C) for specifics on TMDL monitoring requirements. Contact the TMDL manager for needed analyses for TMDL development.

d. Watershed sampling needs will vary by site.

e. Compliance or enforcement monitoring should be done according to permit specifications.

f. In non-scheduled monitoring such as complaints, spills, and other emergencies, the sampling objective will determine what parameters need to be analyzed. If assistance is needed in determining what analyses are needed consult the EAC WPC Manager or other experienced staff for site-by-site analyses determinations.

Table 5: Sample Containers for Surface Water Samples

Sample Container	Collect for Ambient	Collect for Ecosites	Collect for Watershed
1-gallon or 1-liter Routine	X	X	X
Two 250 mL Bacteriological	X	X	X
1-liter Metal	X	X	*
1-500 mL Nutrient	X	X	X
1-500 mL Mercury	X		*

* - Metals should not be routinely sampled at watershed sites. Only request analyses if these are a pollutant of concern.

Due to changes in water quality standards, *E. coli* is the preferred analysis for bacteriological sampling. If the bacteriological sample is collected for TMDL development, check with the TMDL manager for any needed additional analyses. Unless required by study objectives, avoid collecting bacteriological samples during or immediately after storm events.

Changes to criteria have reduced the number of required samples for geometric mean calculation from ten to five samples in a 30 consecutive day period. However, all five of these readings must be measured, not reported as greater than or less than the test detection limit. The criterion also has single sample maximum criteria, which must be measured rather than reported as greater or less than the detection limit. To determine the likely detection limit needed for proper *E. coli* analysis, check the historical data for existing sites. The "Access" Water Quality Database maintained by WPC houses chemical and bacteriological analyses results. Contact the Planning and Standards Section if assistance is needed in locating or using this database.

After historical *E. coli* readings have been determined for a given sampling station, the sampler should determine if a dilution needs to be requested. If historical *E. coli* readings are greater than 1000 colonies/100-milliliters, the sampler should request a 1:100 dilution on the sample tags and the sample request form. If historical readings are less than 1000, no dilution is required and no specific notations need to be made on the sample tags or sample request form. If an *E. coli* count in the Water Quality Database is high and has a denotation of R, for rain event, it is advisable to request both undiluted and 1:100 dilution (Table 7).

When collecting at a new site, the sampler should determine the likely upstream contamination level. If a waterbody is located in an undisturbed area, then an undiluted *E. coli* sample should be sufficient. In an area with likely pathogen sources, such as sewage treatment plant or dairy farms, request a 1:100 dilution. Request both undiluted and diluted (1:100) if the likely pathogen level cannot be determined.

Table 6: Recommended Parameter List for Surface Water Samples

Parameter	Detection Limits	Collect For Ambient	Collect For Ecosites**	Collect For Watershed
Alkalinity	1.0 mg/L	X	X	X
Aluminum, Al	100.0 ug/L	X		O
Ammonia Nitrogen as N	0.02 mg/L	X	X	X
Arsenic, As	1.0 ug/L	X	X	O
Cadmium, Cd	1.0 ug/L	X	X	O
Chromium, Cr	1.0 ug/L	X	X	O
COD	5 mg/L	X		X
Color, Apparent,	PtCoU		X	
Color, True	PtCoU		X	
Conductivity	UMHOS @25 ^{o}C*	X	X	X
Copper, Cu	1.0 ug/L	X	X	O
Cyanide, Cy	0.005 ug/L			
Dissolved Oxygen	mg/L*	X	X	X
E. Coli	cfu/100 mL	X	X	X
Fecal Coliform	cfu/100 mL	X	X	O
Enterococcus	cfu/100 mL		X	
Fecal Strep	cfu/100 mL			
Flow	Cfs*	X	X	X
Iron, Fe	25.0 ug/L	X	X	O
Lead, Pb	1.0 ug/L	X	X	O
Manganese, Mn	5.0 ug/L	X	X	O
Mercury, Hg	0.2 ug/L	X		O
Nickel, Ni	10 ug/L	X		O
Nitrate + Nitrite	0.01 mg/L	X	X	X
pH	SU*	X	X	X
Residue, Dissolved	10.0 mg/L	X	X	X
Residue, Settleable	0.1 mL/L	X		X
Residue, Suspended	10.0 mg/L	X	X	X
Residue, Total	10.0 mg/L	X		X
Selenium, Se	2.0 ug/L	X		O
Sulfates	2.0 mg/L	X	X (69d and 68a only)	O
Temperature	^{o}C*	X	X	X
Total Hardness	1.0 mg/L	X	X	X
Total Kjeldahl Nitrogen (low level)	0.01 mg/L	X	X	X
Total Organic Carbon	1.0 mg/L	X	X	X
Total Phosphorus (low level)	0.004 mg/L	X	X	X
Turbidity	0.1 NTU	X	X	X
Zinc, Zn	1.0 ug/L	X	X	O

*These measurements are taken in the field.

**These analyses are required for Ecosites.

Optional (O) - Should not be collected unless the stream has been previously assessed as impacted by that substance or if there are known or probable sources of the substance.

The sampler should call TDH laboratory and request the readings if *E. coli* results are not received from the TDH Laboratory prior to the next sampling event, so the correct dilution can be requested on subsequent sampling events. If the sampling objective is to compare the geometric mean to the criterion and any of the five readings are reported as greater than or less than the detection limit, then additional samples must be collected until five readings in a 30-day period are achieved.

Table 7: Detection Limit of *E. coli* Test (Quanti-Tray/2000)

Dilution	**Factor**	**Count Range**
None	1X	1 to 2,419
1:10	10X	10 to 24,190
1:100	100X	100 to 241,900

2. Site Selection

Site selection is dependent on the study objectives. After determining the specific objectives of the study and clearly defining what information is needed, select the sampling site in a specific reach of the waterbody. Reconnaissance of the waterway is very important.

Note possible sources of pollution, access points, substrate types, flow characteristics, and other physical characteristics that will need to be considered in selecting the sampling sites. The number and location of sampling stations will vary with each individual study.

Choose a sample location with the greatest degree of cross-sectional homogeneity. The selected sampling location should be well mixed both vertically and horizontally. Since mixing occurs by flow and turbulence, an area downstream of a riffle will insure adequate mixing. In slower moving waters, the mixing zone will extend some distance downstream. It is advisable to avoid confluence areas due to incomplete mixing and changes in flow patterns.

a. For **watershed screenings**, if possible locate sites near the mouth of each tributary. If impairment is observed and time and priorities allow, locate additional sites upstream of the impaired stream reach to try to define how far the impairment extends.

b. For monitoring **point source** pollution, establish a station upstream and downstream, after mixing has occurred, of the source of pollution. If complete mixing of the discharge does not occur immediately, left bank, mid-channel and right bank stations may need to be established to determine the extent of possible impact. Establish stations at various distances downstream from the discharge. Space the collecting stations exponentially farther apart going downstream from the pollution source to determine the extent of the recovery zone.

c. For **targeted monitoring**, avoid locations immediately above, or below the confluence of two streams/rivers, or immediately below point/non-point source discharges. Unless the waterbody is very small or extremely turbulent, an inflow will usually hug the stream bank, for some distance from which it was discharged, with little lateral mixing. This may result in very different chemical analyses and an inaccurate assessment of water conditions. This can be avoided by sampling after mixing has occurred.

d. If macroinvertebrate samples are also collected locate sampling stations for **chemical, bacteriological, and physical parameters** within the same reach (200 meters) as the macroinvertebrate sampling station. If the chemical samples are collected more than 200 meters (0.1 river miles) from the macroinvertebrate collection site, consider it a separate station and assign it a different station ID number.

Protocol B – Assigning Station Identification Numbers

Sampler

Assign station numbers to each site using the following protocol. The station number is used to identify the sample and must be included on all associated paperwork, results, tags, etc. This number is to be used to identify this site every time it is sampled (benthic, fish, algae, bacteria, or chemical). If new stations are set up that will have chemical or bacteriological monitoring, send the station information to the Planning and Standards Section before results are received. (It is usually a least a month between sample collection and receipt of results.) Contact PAS if assistance is needed to assign station numbers. Continue to use the established naming protocol for NPDES effluent samples.

1. Before assigning a new station number, check the Water Quality Database to make sure a number has not already been assigned to that site. Contact the Planning and Standards Section if there is any question. Unless the sites are located upstream and downstream of a point source discharge, tributary confluence or some other factor that would affect the waterbody, stations collected within 200 meters (yards) of each other are considered the same site. Therefore, if chemical and bacteriological samples were taken off the bridge and biological samples were collected up to 200 meters (yards) upstream, they are still the same station.

The only exception to this naming scheme is sites that have been designated as Ecoregion reference sites. These sites are always identified with their ECO designation no matter what the purpose of sampling. If new ecoregion reference sites are added, contact Planning and Standards (PAS) to determine the appropriate station name.

2. If a number does <u>not</u> already exist for the site, create a 12-character identification number. All letters in the station name are capitalized. Do not use more than 12 characters including the decimal.

    a. The first five digits will be the first five letters of the stream/river name (capitalized). If the stream/river name has more than one word, use the first letter of each word finishing out the five letters with the last word. For example, South Fork Forked Deer River would be SFFDE. Do not use the words River, Creek, Branch etc. (Fork is only used if the stream is also designated river, creek, branch etc.) For example, Dry Fork would be DRY but Dry Fork Creek would be DFORK.

    b. The next five characters designate the river mile. This will be written as three whole numbers, a decimal and a tenth space. For example, river mile 1.2 would be written as 001.2.

c. The last two characters designate the county. Use the county identification table in Appendix A to determine the appropriate county designation. The county is expressed with two letters; do not use the numeric state code.

Example 1: A station located at river mile 1.5 on Puncheoncamp Creek in Greene County would be PUNCH001.5GE.

Example 2: A station located at river mile 25 on the North Fork Forked Deer River in Gibson County would be NFFDE025.0GI.

3. Unnamed Tributaries will be named in the following manner.

a. Use the first five letters of the receiving stream the tributary enters.

b. Use 1T for the first unnamed tributary station sampled, 2T for the second unnamed tributary sampled etc.

c. Use a 3-character stream mile including one whole number, the decimal and a tenth space. For example rive mile 1.2 would be written as 1.2.

d. Use the two letter county designation from Appendix A.

Example 1: A station located a river mile 0.2 on an unnamed tributary that entered the North Fork Forked Deer river in Gibson County would be NFFDE1T0.2GI.

Example 2: A second station located at mile 5.5 on the same unnamed tributary would be NFFDE1T5.5GI.

Example 3: A site at river mile 8.5 on a different unnamed tributary to the North Fork Forked Deer would be NFFDE2T8.5GI.

Protocol C –General Collection Procedures

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

The primary objective of surface water sampling is to collect a representative sample that does not deteriorate or become contaminated before it is delivered to the laboratory. Generally, a sub-surface grab sample collected mid-channel is sufficient to document water quality for the space and time in which it is collected. Multiple or composite samples may more accurately represent water quality in large or slow flowing waterbodies.

In streams and rivers shallow enough to safely wade, it is recommended that samples be collected directly into the sample container (Protocol D). If a river, stream, or reservoir is to deep to wade or has dangerous current, mid-channel samples may be collected from a boat (Protocol E) or bridge (Protocol F). For large streams and rivers, composite samples collected at quarter-points may result in more precise representation of water conditions.

Composite or combined samples are composed of a series of discrete, equal samples collected either at equal intervals of time (time composite) or relative to flow (flow proportional). Most commonly, composite samples are collected as part of NPDES compliance monitoring. Composite samples are usually collected with the use of an automatic sampler. See Protocol G for specific information on use of automatic samplers.

If possible, collect samples directly into the appropriate containers (Table 8). If the bottle contains a preservative, do not displace it while filling the container and leave adequate space in the sample bottle for mixing the preservative and the sample. To reduce the risk of bottle contamination, do not open the bottle until the sample is collected.

It is recommended that powder-free latex or nitrile gloves be worn when collecting samples, to avoid contamination of the sample and protect the sampler from possible health risks. In waters know or suspected to have high pathogen levels it is recommended that shoulder length powder-free gloves be worn. If collecting trace-metals or low-level mercury samples, wear powder-free shoulder length gloves (see Trace Metal and Low-Level Mercury Sample Collection, Modified Clean Technique).

To avoid possible cross-contamination, it is recommended that tagged bottles be placed in unused colorless plastic zip-type bag. Store the sample on wet ice in a clean cooler until it is delivered to the lab. Each cooler must contain a temperature blank, used to measure cooler temperature upon arrival in the lab. Unless samples were collected within 2 hours of delivery to the lab, samples warmer than $4^{o}C$ are flagged (Section II.B).

Table 8: Surface Water Sample Specifications

Sample Type	Bottle Type	Preservative	Holding Time
Bacteriological	Two 250 mL bottles	Sodium thiosulfate ($Na_2S_2O_3$)	6 hours
Routine	1 liter or 1 gallon plastic depending on required analyses**	None	48 hours-14 days depending on required analyses**
Nutrient	500 mL plastic	1 mL sulfuric acid (H_2SO_4)*	48 hours -28 days depending on required analyses**
Metals	1 liter plastic	5 mL 70% nitric acid (HNO_3)*	6 months
Mercury	500 mL plastic	2.5 mL 70% nitric acid (HNO_3)*	28 days
Cyanide	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide ($NaOH_9$) at collection. 0.6 gr ascorbic acid ($C_6H_8O_6$) if KI paper indicates chlorine.	14 days
Oil & Grease	1 liter glass, wide mouth	2 mL sulfuric acid (H_2SO_4)*	28 days
Phenols, total	1 liter glass, amber	2 mL sulfuric acid (H_2SO_4)*	28 days
Sulfide	500 mL glass	2 mL zinc acetate (ZnAc) in lab. 5 mL 50% sodium hydroxide (NaOH) in field	7 days
Boron	125 mL plastic	0.75 mL hydrochloric acid (HCl)*	6 months
Flash Point	16 ounce glass jar with Teflon® lid	None	None
TCLP	16-ounce glass jar	None	6 months
TOC	125 mL plastic	0.25 mL sulfuric acid (H_2SO_4)	None specified
NPDES Extractables	1 gallon amber bottle, acetone-rinsed, and Teflon®-lined cap	None	7 days to extract; 40 days to analyze
Pesticides/PCBs			
TAL Extractables			
Nitrobodies			
Semivolatiles			
NPDES Volatiles	Four 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)*	14 days
TAL Volatiles			
BTEX	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)*	14 days
GRO			
EPH	One 1-gallon amber bottle with Teflon® lined lid	1:1 hydrochloric acid (HCl)*	14 days

Store all samples on wet ice after collection.
*In very hot weather, store empty pre-preserved containers on ice to avoid vaporization.
**The specific parameters that can be analyzed from each sample are listed in Appendix B.

Sample Request Sheet and Chain of Custody Information

Following the sample collection, complete the sample tag (Protocol H) and the Sample Request Form (Protocol I). When collecting scheduled samples, much of this form may be completed before arrival at the sampling location. Pre-printed forms and labels may expedite scheduled sampling. In the header information, complete the sampler's name, collection date and time (military) after the sample is collected. Record the water parameters in the field determination box (Protocol J).

From the time of collection until analyses, custody of the sample must be traceable to assure integrity of the sample. A sample is considered to be in the custody of the sampler if it is in the sampler's possession or secured in a tamper-proof way in a restricted area. Make sure the doors are locked, if the sample is left unattended in a vehicle.

The sampler, signs the "Collected by" line under chain of custody and fill in the date and military time of collection (Section II.C). The entire chain of custody must be completed (Protocol I). If the sample is given to anyone else (TDEC staff, courier, etc.) for transport to the laboratory, then they are responsible for the integrity of the sample and must sign the chain of custody on the Sample Request Form when taking custody of the sample.

Custody Seal

A custody seal assures the sample integrity has not been compromised. It is recommended that once samples have been placed on ice in the cooler, a signed and dated custody seal be attached to the cooler in such a way that it must be broken to open the cooler. A signed and dated custody seal (Figure 1) is only required if the sample is transferred from the sampler's custody (i.e. other TDEC staff, bus, courier, etc.) before reaching the laboratory. Any signed and dated custody seal may be used.

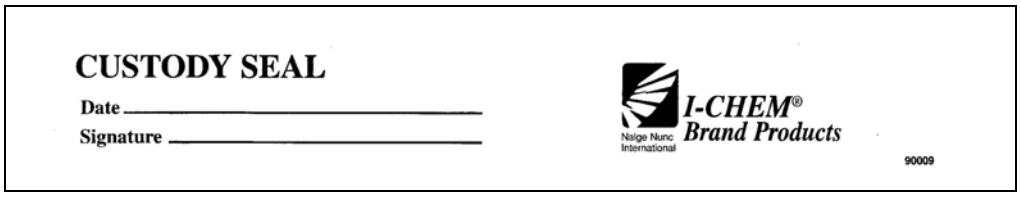


Figure 1: Custody Seal Example.

Sample Types

The specific type of chemical or bacteriological sample that needs to be collected will vary with the sampling objectives and funding priorities. The most common sample types are discussed below. If additional samples are collected, contact the receiving laboratory for collection instructions.

1. Bacteriological Sample Collection

For bacteriological samples, collect two 250-milliliters sterilized pre-preserved bottles to ensure an adequate sample volume is available for analyses. Do not open the sterilized bottle until the sample is collected. When handling the sample container take care not to contaminate the lid or the inside of the bottle. It is recommended that shoulder length gloves be worn in waters known or suspected to have high pathogen levels to protect the sampler from possible health risks. Do not overfill the bottle and displace the preservative. After filling the bottle, carefully replace the lid and shake the bottle to assure adequate mixing of the sodium thiosulfate. Do not use any equipment that has not been sterilized to collect bacteriological samples.

After the lids have been placed on the bottles, attach a completed sample tag to each bottle. Fill in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers on the sample tag. The two bottles are considered one sample, so write the same collection time on both tags. Check "yes" under preservative and place an "X" beside Microbiological.

If chemical analyses are also requested, the microbiologists may not receive their copy of the Sample Request Form before the sample is analyzed; therefore write the needed analyses (i.e. *E. coli*, fecal coliform, and/or fecal strep.) and if dilution is requested in the remarks box on the sample tag. For *E. coli* analysis, if historical readings have been higher than 1000, request in the remarks box that sample be diluted 1:100. If historical *E. coli* readings have been less than 1000, no specific notations are needed. Refer to Protocol A for additional guidelines for determining if diluted sample analysis should be requested.

To avoid cross-contamination, it is recommended that tagged bottles be placed in a colorless zip-type plastic bag and then stored on ice in a sealed cooler until delivered to the lab. Make sure each cooler contains a temperature blank, which is used to measure cooler temperature upon arrival in the lab. Bacteriological samples should be no warmer than $4^{o}C$, unless they are collected within 2 hours of delivery to the laboratory. Bacteriological samples must be delivered to TDH Microbiology Laboratory or any other TDEC contract laboratory within 6 hours of the collection time. Check with the receiving laboratory for hours and days bacteriological samples are accepted (Table 2). If another TDEC contract laboratory is used, check with them on the days and times samples are accepted.

2. Inorganic Sample Collections

a. Routine Sample Collection

Routine samples require no preservative and are collected in pre-cleaned single use gallon or liter plastic bottles. See Appendix B for the volume of sample required for various routine analyses. If multiple analyses are requested, collect a gallon of sample water. Contact the receiving laboratory if there is a question about of the volume of sample to collect for proper analyses and QC.

After the sample container is filled, complete the sample tag by writing Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under Preservative. Write Routine in one of the empty lines under Analyses. Attach the completed Routine tag to the filled sample bottle, place it in a zip-type plastic bag (optional) and store on ice until delivery to the laboratory.

b. Nutrient Sample Collection

Nutrient samples are collected in pre-cleaned, single-use 500-milliliters plastic bottles preserved with 1-milliliter sulfuric acid. In hot weather, store acid pre-preserved bottles on ice until needed to avoid vaporization and a potentially hazardous situation. Use only phosphate-free soap for hand washing or sampling equipment cleaning prior to obtaining nutrient samples. Always wear powder-free gloves when collecting nutrient samples. Fill the sample bottle with sample water, but do not overfill the bottle and displace the preservative. Note that nitrite and orthophosphate samples are analyzed from the routine sample bottle and are not preserved.

Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Under Analyses check the COD, TOC, Nutrient line and circle Nutrient. Attach the completed Nutrient tag to the filled sample bottle and place it in a zip-type bag (optional). Store the sample on ice until delivery to the laboratory.

c. Routine Metals and Mercury Sample Collection

Routine metal samples are collected in pre-cleaned, single-use 1000-milliliters plastic bottles preserved with 5-milliliters nitric acid. Mercury samples are collected in pre-cleaned, single use 500-milliliters plastic bottles preserved with 2.5-milliliters nitric acid. In hot weather, store acid pre-preserved bottles on ice until needed to avoid vaporization and a potentially hazardous situation.

Most metal samples may be collected using the same collection techniques used to collect other chemical samples. EPA has recommended that any intermediate sampling devices used to collect mercury samples be constructed of Teflon®. If trace metals or low-level mercury are a concern, collect samples using the modified clean technique specified in the following section.

Fill the sample bottle with sample water, but do not overfill the bottle and displace the preservative. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Under Analyses, check the "Metals" line. Attach the completed Metals tag to the filled sample bottle, and place it in a zip-type bag (optional). Store the sample on ice until delivery to the laboratory.

d. Trace Metals and Low-Level Mercury Sample Collection Modified Clean Technique

This sampling method is adapted from U.S. Environmental Protection Agency. 1996. *Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels.* Office of Water Engineering and Analysis Division (4303). Washington, DC.

The modified clean technique is used for trace metal and low-level mercury collections. This method is not intended for collection of metals or mercury to be analyzed at minimum detection levels (MDL) available at most environmental laboratories including the TDH Environmental Laboratories. Only ultra-clean laboratories are able to obtain MDL necessary to analyze samples for trace metals.

It cannot be overemphasized how easily samples can be contaminated with trace metals. The detection levels for most metals are parts-per-billion (ug/l) or parts-per-trillion range. The modified clean sampling method is designed to reduce the probability of contamination when collecting a sample to be analyzed for trace metals.

Many lotions, sunscreens, and insecticides contain trace amounts of metals and should not be worn when collecting trace metal samples. Atmospheric metals from automobile exhaust, cigarette smoke, bridges, wires or poles can also contaminate the sample. To avoid possible contamination, collect trace metal and low-level mercury samples at least 100 yards upstream of bridges, wires, poles, or roads.

Wear powder-free latex or nitrile gloves when handling sample containers. Talc gloves contain high levels of zinc and are likely to contaminate the sample, and must not be used. If more than one sample is collected on the same waterbody, collect in the area believed to have the lowest metal contamination level first and the area with the highest metal concentration last.

A 1-liter pre-cleaned, single use plastic bottle preserved with 5-milliliters nitric acid provides sufficient sample volume for all metal analyses except mercury. Due to the volume of sample needed for Mercury (Hg) analysis, collect a separate mercury bottle. Mercury samples require 500-milliliters volume of sample preserved with 2.5-milliliters of nitric acid.

Designate one sampler as “clean hands” and the other as “dirty hands”. The “clean hands” designee conducts any activities involving the sample container and inner storage bag. The “dirty hands” designee is responsible for all other activities. The “clean hands” designee wears shoulder length powder-free gloves during the sampling event. The “dirty hands” designee may wear short powder-free gloves.

The "dirty hands" designee removes the sample containers from the cooler and opens the outer bag. The "clean hands" designee opens the inner bag, removes the sample container and moves to the appropriate sampling area. Then the "clean hands" designee removes the container lid and fills the sample container(s) upstream of all water movement, being careful not to displace the preservative. After the sample bottle is filled, the "clean hands" designee replaces the lid tightly, shakes the bottle to mix the preservative and returns it to the sample staging area.

The "dirty hands" designee completes the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Under Analyses, check box beside Metals. For mercury samples, write "Mercury" in one of the blank lines under Analyses. Attach the tag to the sample. "Clean hands" designee then places the sample in the inner zip bag and seals it. The "Dirty Hands" designee seals the outer zip bag and places the sample on wet ice in a clean non-metallic cooler with a temperature blank.

Trace metal and low-level mercury samples cannot be collected from a bridge or pier due to likely contamination from the structure. In non-wadeable rivers or reservoirs, if possible collect metal and mercury samples from a boat constructed of a non-metal material like plastic or fiberglass. When feasible, paddling or electric motors are preferable to gasoline motors, since gasoline is a potential source of contamination. If the waterbody is too large to gain access to the sampling location without the use of a gasoline motor, turn off the motor a sufficient distance from the sampling location to avoid contamination and paddle the remainder of the way to the sample location.

Always approach the sampling location from downstream. The "clean hands" designee may collect subsurface grab samples from the bow of the boat. If the study objective requires a mid-depth sample in non-wadeable waterbodies, collect the sample with the use of a properly cleaned (Section I.H) discrete depth sampler (Kemmerer) constructed of Teflon® with no metal parts. Only the "clean hands" designee is to handle the Kemmerer, sample bottles and the inner zip bag. The "dirty hands" designee controls the boat location and handles all non-sample contact duties.

e. Cyanide Sample Collection

Cyanide analysis requires a 1-liter sample collected in a pre-cleaned, single use plastic bottle. Test the sample for the presence of chlorine by dipping Potassium Iodine (KI) paper into the sample. If the KI paper turns blue indicating the presence of chlorine, neutralize the chlorine with 0.6 grams of ascorbic acid. If sulfides are suspected, test for the presence of sulfides by placing a drop of sample on acidified lead acetate test paper. If the paper darkens, indicating the presence of sulfides, add lead acetate until the test paper does not change color. After chlorides and/or sulfides have been tested for and neutralized if needed, field preserve cyanide samples to a pH greater than 12 by adding 5-milliliters of 50 percent sodium hydroxide to the sample.

Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Place an "X" in the box beside Cyanide. Tighten the lid on the sample bottle and attach the completed tag to the sample bottle, place in a zip-type bag (optional) and store on ice until delivery to the lab.

f. Oil and Grease Sample Collection

Oil and Grease analyses require at least 1-liter sample collected in a wide mouth glass jar preserved with 2-milliliters sulfuric acid. Consult the receiving laboratory to determine if more than 1-liter sample is needed to achieve a homogeneous sample. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Write "Oil and Grease" on the empty line under Analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

g. Phenols Sample Collection

Phenol analysis requires 1 liter of sample collected in an amber glass jar preserved with 2-milliliters of sulfuric acid. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Write "Phenols" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

h. Sulfide Sample Collection

Sulfide analysis requires 500-milliliters of sample collected in a glass jar. Sulfide samples are preserved in the laboratory with 2-milliliters of zinc acetate and in the field with 5-milliliters of 50 percent sodium hydroxide. Do not displace the preservative while filling the jar. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Write "Sulfide" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the lab.

i. Boron Sample Collection

Boron analysis requires 125-milliliters of sample collected in a plastic bottle preserved with 0.75-milliliter of hydrochloric acid. Do not displace the preservative while filling the bottle. Attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Write "Boron" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the lab.

j. Flash Point Sample Collection

Flash point is a regulatory test to determine if a substance is flammable at temperature below 60°C. Therefore, do not subject any suspected substance to heat or possible ignition source. Flash point analysis requires collection in a 16-ounce glass jar. No preservative is needed.

Fill the jar with sample water and attach a completed sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Write "Flash Point" on an empty line under analyses. Place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

k. TCLP Sample Collection

Total Characteristic Leaching Procedure (TCLP) test is used to simulate the mobility of metals from wastes. This is most commonly a regulatory test performed on wastes and soils collected from landfills (Solid Waste) or superfund sites. This test has specific requirements. If the sample contains less than 0.5 percent solids, the liquid is classified as TCLP extract. If the sample contains more than 0.5 percent solids, enough sample must be filtered to get at least 100 grams of solids to perform the extraction. It could take copious amounts of sample to obtain 100 grams of solids.

Collect TCLP samples in a clean 16-ounce glass or plastic jar with no preservative. A great deal more sample may be required if more than 0.5 percent solids are found in the initial analysis. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Write "TCLP" in one of the empty lines under analysis. Attach the completed TCLP tag to the sample bottle, place it in a zip-type bag (optional) and store on ice until delivery to the laboratory.

l. Total Organic Carbon Sample Collection

TOC is typically analyzed from the nutrient sample. If nutrient samples are <u>not</u> collected and only Total Organic Carbon (TOC) is needed, collect sample in a 125 milliliter plastic bottle preserved with 0.25 milliliter of sulfuric acid. Do not displace the preservative while filling the bottle. Complete the sample tag by filling in Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Write "TOC" in one of the empty lines under Analyses. Attach the completed TOC tag to the sample bottle, place it in a zip-type bag (optional), and store on ice until delivery to the laboratory.

3. Organic Sample Collections

a. Base/Neutral/Acid Extractable Compounds

(1). NPDES Extractable Sample Collection

NPDES Extractable analyses require a one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Place an "X" beside Extractable Organics and write "NPDES" on one of the blank lines under analyses. Attach the tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(2). Pesticides/PCBs Sample Collection

Pesticide and PCBs analyses requires one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Place an "X" beside pesticides/PCBs under Analyses. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(3). Target Analyte List Sample Collection

Target Analyte List (TAL) analyses requires one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Write "TAL" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(4). Nitrobodies Sample Collection

Nitrobodies tests are run to analyze for six explosive compounds, so handle these samples very carefully and protect the sample from heat sources. Nitrobodies analyses requires one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed.

Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Write "Nitrobodies" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

(5). Semivolatiles Sample Collection

Semivolatiles analyses require one-gallon sample collected in an acetone-rinsed amber glass bottle with a Teflon® lined lid. No preservative is needed. Fill the bottle with sample water and complete a sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "no" box under preservative. Write "Semivolatiles" in one of the blank lines under Analyses and place an "X" in the box to the right. Attach the sample tag to the bottle and place the sample in a zip-type bag (optional) and store on ice until delivery to the laboratory.

b. Volatile and Petroleum Hydrocarbon Compounds

Since volatile organic compounds may be present in concentrations of micrograms per liter, they may be lost when improperly handled. Avoid sampling in turbulent areas. Collect volatile organic samples directly into the appropriate pre-preserved amber vial or bottle (Table 4). All lids used for volatile organic samples must be Teflon® lined. Pour the sample slowly down the side of the container to avoid turbulence that could produce volatilization.

Slightly overfill vials to produce a convex meniscus. The lid may be used to capture a small amount of sample to help produce the convex meniscus. A small amount of overflow should occur when the lid is tightened down. After placing the lid tightly on the bottle, invert it and tap on the bottle while watching for air bubbles. If any bubbles are present, repeat the process with another clean preserved vial.

(1). NPDES and TAL Volatile Sample Collection

To collect a NPDES or TAL volatile sample, fill four 40-milliliters amber pre-preserved vials. Each vial is pre-preserved with 1:1 hydrochloric acid. To keep the sample together, place a rubber band around the four vials. Fill out one tag and attach it to all four vials. Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Mark the box beside Volatile Organics under Analyses and write the specific requested analyses in one of the empty lines. Place all four vials in a zip-type colorless plastic bag (recommended) and store on ice in a clean cooler until delivery to the laboratory for analyses.

(2). BTEX and GRO Volatile Sample Collection

To collect a BTEX or GRO volatile sample, fill five 40-milliliters amber pre-preserved vials with Teflon® lined septa caps. Each vial is pre-preserved with 1:1 hydrochloric acid. To keep the sample together place a rubber band around the five vials. Fill out one tag and attach it to all five vials.

Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Place an "X" in the box beside Volatile Organics under Analyses and write the specific requested analyses in one of the empty lines. Place all five vials in a zip-type colorless plastic bag (recommended) and store on ice in a clean cooler until delivery to the laboratory for analysis.

(3). EPH Volatile Sample Collection

To collect EPH volatile sample, fill one 1-gallon pre-preserved amber bottle with a Teflon® lined lid. The bottle is pre-preserved with 1:1 hydrochloric acid. Complete the sample tag with Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location and Samplers. Check the "yes" box under preservative. Place an "X" in the box beside Volatile Organics under Analyses and write EPH in one of the empty lines. Store the sample on ice in a clean cooler until delivery to the laboratory for analysis.

Protocol D – Surface Water Collections in Wadeable Rivers and Streams

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

In streams and rivers shallow enough to wade (generally less than 4 feet, unless there is a strong current)**,** submerge the sample container directly in the water column (grab sample) to collect the sample. Wading is appropriate if the stream has a noticeable current and the samples are collected upstream of all movement. If multiple sample containers are going to be filled at the same station, fill the unpreserved sample (routine) first. Collect subsequent samples upstream of the previous sample to avoid possible contamination from the substrate or previous preservatives.

To collect a surface water sample using the sample container, wade to the thalweg, face upstream and collect the sample without disturbing the sediment. If sediment disturbance is unavoidable collect the sample upstream of the sediment plume or wait until the disturbed sediment moves downstream. Remove the lid without contaminating the lid or the inside of the sample container. Grasp the bottle near the base and dip it midway in the water column with a forward upstream motion. If the sample bottle contains a preservative, do not overfill it and displace the preservative. Tightly replace the lid and shake preserved bottles to assure adequate mixing of the preservative.

After collecting the sample, wade back to the sample staging area and attach a completed sample tag to the bottle. Place the sample inside a zip-type bag (optional) and store on ice until delivery to the laboratory. See Protocol C for general collection techniques and additional precautions when collecting trace metal or low-level mercury samples. Protocols H and I describe the procedure for completing sample tags and Sample Request Forms.

Protocol E – Surface Water Collections from a Boat

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

In streams, rivers, reservoirs, or lakes too deep for wading the best means of obtaining water samples is from a boat either directly into the sample container or with the use of a discrete depth sampler. Make all collections from the bow of the boat while the boat is facing upstream. Collect the samples upstream of the boat's movement. If multiple sample containers are going to be filled at the same station, fill the unpreserved sample (routine) first. Collect subsequent samples upstream of the previous samples to avoid possible contamination from prior preservatives.

Collect subsurface grab water samples from the bow of the boat while the boat is facing upstream. Remove the lid without contaminating the lid or the inside of the sample container. Grasp the bottle near the base and dip it in the water column with a forward upstream motion. If the sample bottle contains a preservative, do not overfill it and displace the preservative. Tightly replace the lid and shake preserved bottles to assure adequate mixing of the preservative.

To collect mid-depth samples, use a discrete depth sampler, such as a Kemmerer. Any equivalent discrete depth sampler may be used as long as it samples from the desired depth, is constructed of a material that will not contaminate the sample, such as Teflon®, and is easily cleanable. Reusable discrete depth samplers cannot be sterilized; therefore, bacteriological samples cannot be collected with this equipment.

The location and number of samples will vary depending on the purpose of the sample. In reservoirs and lakes with little flow, multiple samples may be required to accurately represent water conditions. Composite samples collected at quarter-points may more accurately represent water conditions for large bodies of water.

A Kemmerer is a cylinder, with Teflon® or silicone stoppers on each end, attached to a rope. The rubber stoppers can be closed remotely with a weighted messenger. Lock the stoppers in the open position to allow water to flow though the device as it is lowered to the correct depth.

When the Kemmerer reaches the proper depth (usually mid-depth), slide the messenger down the rope to close the stoppers and capture a water sample. Raise the Kemmerer out of the water by the rope. Open the valve on the Kemmerer to fill the appropriate sample bottles. Repeat this process as many times as necessary to collect a sufficient volume of water to fill all sample bottles.

Collect an equipment blank (Section II.B), before the sample is collected, on the clean discrete sampling device at 10 percent of the sampling events to assure the sample is not being contaminated by collection equipment. Before reusable equipment such as a Kemmerer can be used, it must be properly cleaned to avoid the possibility of cross-contamination. See Section I.H for laboratory cleaning procedures. If it is not possible to return the to EAC lab between uses, discrete or intermediate sampling devices may be field cleaned between sites using the following field cleaning procedure.

Measure water quality parameters (DO, pH, temperature, and conductivity) at each sample site. If the cord on the water parameter probe is long enough to reach mid-depth in waters 10 feet deep or less, lower the probe to the mid-depth and allow it to equilibrate. For sampling in waters deeper than 10 feet, measure the water parameters at a depth of 5 feet, unless a different depth is specified in the criteria or by the study objectives. Some studies may require additional readings to measure water quality profiles.

Field Cleaning Procedures for Sampling Equipment

All reusable equipment that comes in direct contact with sample water must be cleaned between uses. If it is not possible to return to the EAC lab to clean sampling equipment between uses, it may be cleaned in the field. Replace any contaminated tubing between sites. Document any deviation from this procedure.

1. **Soap Wash** – Wash the equipment with phosphate-free laboratory detergent such as Alconox® or Sparkleen® and tap water. The soapy water can be dispensed from a squeeze bottle. Use a clean scrub pad to remove any surface film or particulate matter.

2. **Tap Water Rinse** – Rinse the equipment thoroughly with tap water from a squeeze bottle. Store tap water in any clean and covered tank or bottle.

3. **Deionized Water Rinse** – Rinse equipment thoroughly with deionized water using a squeeze bottle. Store deionized water in a labeled, clean covered glass or plastic tank or bottle. If the sampling equipment is being cleaned for the collection of organic samples, rinse with organic free reagent grade water dispended from Teflon® squeeze bottle.

4. **Storage –** Store equipment in a clean area until used.

5. **Sample Water Rinse -** At the site before collecting the sample, rinse the sampling equipment at least twice in the creek, river, or reservoir water.

Protocol F – Surface Water Collections from a Bridge or Pier

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

The primary concerns when sampling from a bridge is the safety of personnel and the integrity of the water sample. For the safety of staff as well as motorists, follow OSHA precautions from *Manual on Uniform Traffic Control Devices* (1993) outlined in Procedure I.D. If the stream is wadeable, it is recommended that samples not be collected from the bridge. Generally, the sample should be collected in the thalweg. The location, depth, and number of samples will vary depending on the purpose of the study.

If possible, collect the samples from the upstream side of the bridge. Handle the sampler carefully to avoiding dislodging dirt and other contaminates from the bridge into the sample container or sampling device. While collecting the sample, be careful to avoid getting sediment in the sample container or intermediate sampling device.

1. Subsurface sample collection

Subsurface samples may be collected from a bridge or pier directly into the appropriate sample container with the use of a bottle holder connected to a long handle or an intermediate sampling device. If an intermediate device is used, collect an equipment blank (Section II.B) at 10 percent of the sampling sites after the equipment is cleaned and before samples are collected to assure they are not being contaminated by the collection method.

Due to likely contamination, chemical samples may not be collected from a PVC plastic bucket or bailer. A properly cleaned (Protocol E) Teflon® or High Density Polyethylene (Nalgene®) bucket or bailer may be used to collect metals (other than trace level metal or mercury), nutrient, and routine samples. EPA recommends use of a Teflon® bucket or bailer to collect mercury samples. Samples for trace metal analyses must be collected using modified clean technique (Protocol C).

Subsurface organic samples may be collected with the use of a properly cleaned stainless steel bucket or bailer. Bacteria samples must be collected using a sterile container. Subsurface bacteria samples may be collected from a bridge, pier, or bank directly into a sterile sampling container using a bottle holder connected to a long handle or into a sterile intermediate sample container. Sterile disposable containers or intermediate samplers that can be sterilized without being damaged by autoclaving may also be used to collect bacteriological samples.

2. Mid-depth sample collection

If the study objective requires mid-depth chemical sample collection, a discrete depth sampler may be used to collect mid-depth samples. See Protocol E for specifications, use, and field cleaning procedures of discrete depth samplers. Protocol I.H discusses lab-cleaning procedures for sampling equipment. Collect an equipment blank (Section II.B) on 10 percent of the samples collected using discrete depth sampler to assure the sample is not being contaminated by collection equipment.

A peristaltic pump may also be used to collect chemical water samples if the bridge is no more than about 25 feet above the water surface. A weighted line attached to the tubing may be lowered into the water to any depth. The pump can pull a surface water sample through the tubing around 25 vertical feet. The appropriate sample containers may be filled directly from the outlet tubing attached to the pump.

Since neither the discrete depth sampler nor the peristaltic pump can be sterilized, bacteriological samples cannot be collected using these devices.

3. Water Parameter Readings

If the cord on the water parameter probe is not long enough to reach from the bridge to the water, a plastic (PVC is acceptable for this use) bucket attached to a rope may be used to collect water for reading water parameters. Rinse the bucket (Section I.H) twice with surface water before the water is collected for the water parameter readings. If the bucket gets visibly dirty, muddy or oily clean the bucket according to the field cleaning procedure in Protocol E. Rinse the probe with surface water from the site before placing it in the bucket to read water parameters.

Fill the bucket with surface water and retrieve it with the rope. Place calibrated instantaneous water parameter meter(s) in the bucket of surface water and allow it to equilibrate before recording results. For duplicate readings, dump the water from the initial reading and refill the bucket with surface water. Then place the probe in the bucket and allow it to equilibrate. If water parameters will be taken from the same bucket used to collect chemical surface water samples, fill chemical sample container before taking water parameter readings.

Protocol G –Composite Sample Collection

Sampler

Adapted from U.S. Environmental Protection Agency. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

This method is a standardized way of collecting a representative composite sample, insuring that it does not deteriorate or become contaminated before delivery to the laboratory. Composite samples are most commonly collected as part of NPDES compliance monitoring although it may be appropriate for other types of studies. When collecting a compliance sample, most aspects of monitoring, including sampling location and sample collection method, will be specified in the NPDES permit. If the sampling location is not specified in the permit, collect the sample between the last discharge and the receiving water. Generally, mid-depth, center of the flow, in an area with the highest turbulence is the best location for the intake line.

A composite sample is a combined or composited series of discrete, equal samples collected over a temporal or spatial range. Time (temporal) composite samples are made up of a number of discrete samples of equal size collected at equal time intervals into one container. Flow proportioned (spatial) composite samples are composed of a number of samples sized relative to the flow. Automatic samplers may be used to collect composite samples either for collecting several aliquots at frequent intervals or to collect continuous samples. Flow proportional samplers are activated and paced by a compatible flow meter. The choice of time composite or flow proportional depends on permit requirements, variability of flow and concentration of pollutants.

Any automatic sampler meeting the following specifications may be used to collect composite samples. It is preferable to use one of TDEC's automatic samplers, however, if field conditions do not allow for the installation of TDECs automatic sampler and the facility's automatic sampler meets these specifications, the facility's sampler may be used.

Automatic Sampler Specifications:

- Automatic sampler must provide refrigeration either by mechanical means or ice.
- Automatic sampler shall be capable of collecting a large enough sample for all parameter analyses (each aliquot must be at least 100-milliliters).
- Automatic sampler must have adjustable sample volume.
- Automatic sampler must provide at least 20 feet of lift.
- Pumping velocity must be at least two feet/second.
- Minimum inside diameter of intake line is ¼ inch.
- No PVC plastic or metal parts may come in contact with the sample water if it is be analyzed for organics or metals.

1. Cleaning and Maintenance

Remove contaminated tubing before cleaning and replace with new tubing before next sample collection. Thoroughly clean the automatic sampler between uses, (Section I.H) and check for any damage or needed repairs. Inspect the desiccant and batteries and replace if necessary. Test the manual and automatic operation of the automatic sampler to make sure it is operating correctly. Check the pumps function in forward, reverse, automatic, and run the automatic sampler through at least one purge-pump-purge cycle and compare function against manufacturer's specifications.

Follow manufacturer's instructions to make any needed repairs or calibration changes. Develop calibration and use SOPs for each brand and/or model of automatic sampler used in each EAC. Keep all calibration and repair records in a bound logbook.

2. Safety

It is recommended that powder-free latex or nitrile gloves be worn when installing sampling equipment or collecting samples to avoid contamination of the sample and to provide protection from possible health risks.

3. Installation of Automatic Sampler

Power must be available for the entire sampling event. If accessible, the facility's power may be used. If the facility's power is not available, then generator or battery power must be used. Install new tubing (Silastic®, or equal, in the pump and Tygon®, Teflon®, or equal in the sample train) in the automatic sampler before deployment. Collect an equipment blank on the automatic sampler at ten percent of the sites.

Before installation, test the rinse, purge-pump-purge cycle at least once. Also, check the pump volume at least twice using a graduated cylinder. Each aliquot must be at least 100-milliliters. Test flow proportional automatic sampler operation with the flow meter to make certain it is operating properly.

After the automatic sampler and tubing is placed in the proper location, program the sampler. For time composite samples, program the automatic sampler to collect at least 100-milliliters aliquots at the permit specified frequency. For flow proportional samples, program the automatic sampler to collect at least 100-milliliters aliquots at intervals based on the flow.

The final total volume must be sufficient to conduct all required analyses, for either collection method. If possible, install the automatic sampler where specified in the permit. Position the intake to draw wastewater from the mid-channel at mid-depth. If a facility disinfects with chlorine, install the automatic sampler upstream of chlorinator.

4. Special Precautions for Metal and Organic Samples

If metal samples are to be collected, rinse the entire automatic sampler with reagent grade water. Pump about a half a gallon of reagent grade rinse water through the system and discard. For organic samples, use organic free reagent grade water for rinsing and flushing. Pump about one and a half gallons of organic free reagent grade water into the composite sample container for distribution into the appropriate blank container.

For metal samples, add nitric acid to the metals blank container for preservation. If the automatic sampler tubing is attached to a metal conduit pipe, install the intake tubing upstream. Wrap the submerged portion of the conduit pipe with a protective barrier such as duct tape.

5. Securing Automatic Sampler

Secure the automatic sampler in such a way as to prevent tampering with the sample. At a minimum, place a lock and/or signed and dated custody seal on the automatic sampler housing. Some locations may require additional security measures. Custody seals may also be placed on sampling pole and tubing line.

6. Retrieving the Automatic Sampler

When the compositing period has ended, remove the sample from the automatic sampler and thoroughly mix the composite sample. After the sample is well mixed, pour the composite sample into the appropriate, properly preserved sample container(s). Attach a completed sample tag to each sample bottle and complete the Sample Request Form. Write the Site No. (sample ID), two-digit Tennessee County Code, Date, Military Time, Station Location, and Samplers on the sample tag. Check the “Composite (Comp.)” box under Designate, mark the sample type and if it contains a preservative. Place the labeled sample bottle in a zip-type bag (optional) and store in a cooler on ice until delivery to the laboratory.

For routine inspections, offer the permittee a split sample. Collect all sampling equipment and perform appropriate cleaning and maintenance on the automatic sampler upon return to the EAC.

Protocol H - Sample Identification Tags

Sampler

Each sample must be correctly identified as to where, when, and by whom it was collected, how it was preserved and what analyses are needed. TDH Environmental Laboratory provides sample tags that have been approved by EPA (Figure 2). If using another TDEC contract laboratory, obtain tags containing the same identification information, from that contract laboratory. Use only waterproof, non-erasable ink on the sample tags. Roller ball and gel pens are not waterproof. If a sticker label is attached to the sample tag, it must adhere well enough that it cannot be removed without damaging the tag. Clear packaging tape may be applied over a completed sample tag to assure the sticker will adhere and prevent the ink from smudging. Write legibly. All tags must include the following identification information.

1. **Program/Billing Code** – Write the billing code of the program area that will pay for the analyses of the sample. Only approved billing codes may be used.

2. **Site No.** – Write the site number or station ID number that uniquely identifies where the sample was collected. This must be filled in. (For example PUNCH001.5GE. See Protocol B for specifics on assigning station numbers.)

3. **County Code** – Write the two-digit Tennessee County Code number, Tennessee County Number (TN CO NO). (See Appendix A for a complete county list.)

4. **Month/Day/Year** – Write the date the sample was collected.

5. **Time** – Fill in the time the sample was collected recorded in military time (24-hour clock).

6. **Designate** – Indicate whether the sample was a composite (comp.) or grab.

7. **Station Location** – Write a description of the location at which the sample was taken.

8. **Samplers** – At least one sampler signs their full name.

9. **Preservative** – Mark the appropriate box. No, if the sample is not preserved. Yes, if the sample is preserved.

10. **Analyses** – Place a check or X beside the general type of analysis to be preformed on the sample. If the needed analyses are not listed, write in the analyses type on one of the blank lines under Analyses.

11. Remarks – Write comments regarding the sample in the remarks box. Label quality control samples, such as duplicates, field blanks, trip blanks, or equipment blanks in this box. For bacteriological analyses, list the type of analysis needed and if dilution is required. (See Protocol A for additional information on bacterial analyses.)

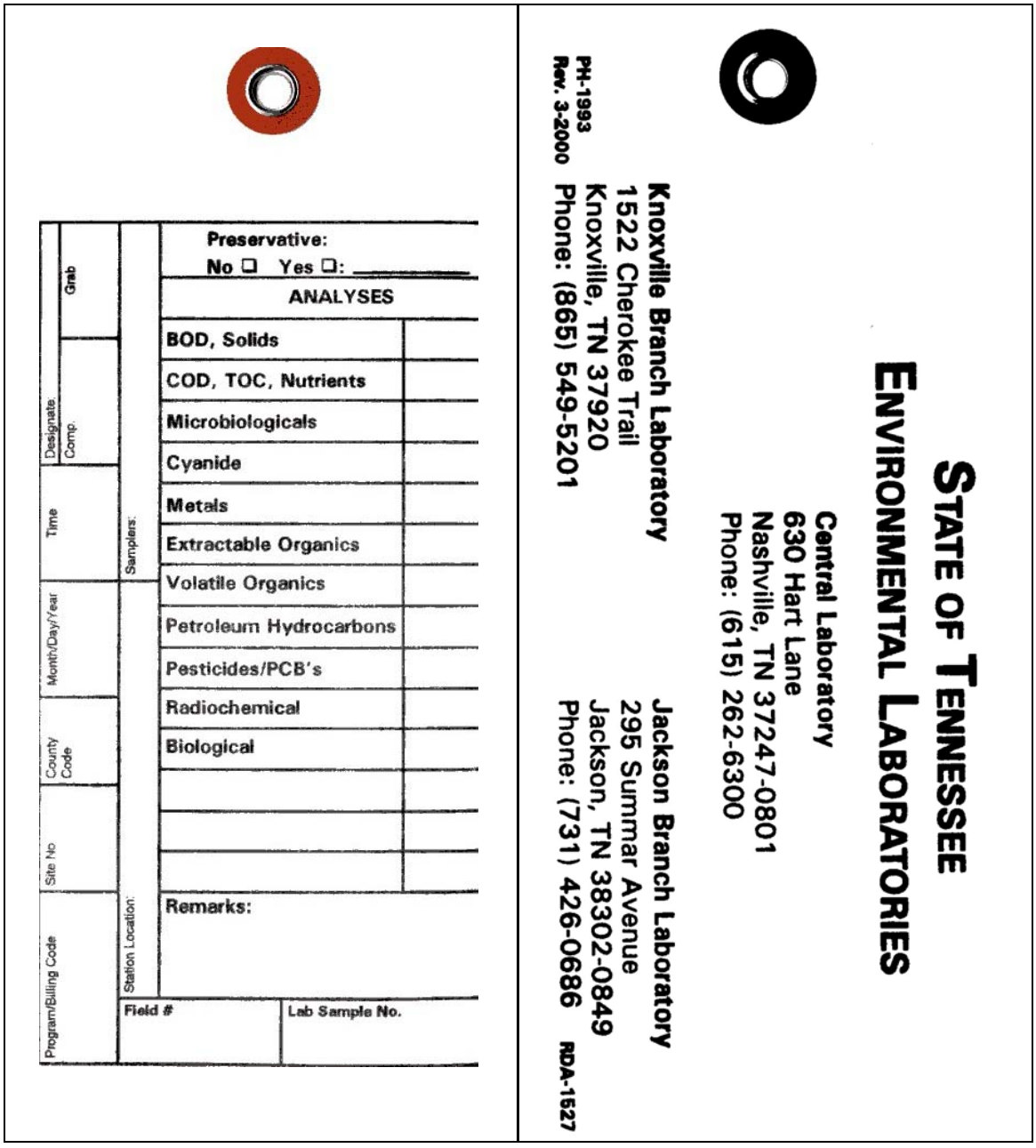


Figure 2: External Sample Tag.

Protocol I - Sample Request Forms

Sampler

Write legibly and complete all information on the Sample Request Forms. The TDH Environmental Laboratory provides Sample Request Forms, printed on No Carbon Required (NCR) paper. Always use the most recent version of the Sample Request Form. Keep the yellow copy of the Sample Request Form in the project file.

If using another TDEC contract laboratory, obtain the appropriate sample request sheets from the contract laboratory. Complete a separate Chain of Custody (Appendix A) if any sample request sheet other than those provided by TDH Environmental Laboratory is used. All sample request forms must include the following information.

1. Header Information

Completely fill out the gray portion in the upper left hand corner of the TDH Environmental Laboratory Sample Request Form (Figure 3).

a. Project/Site No. – Fill in the unique number, if any, which is designated by the program area/sampling agency. This does not need to be filled in if no project number is associated with the sample.

b. Project Name – Write the specific project name or focus of the field investigation in this blank. If a name is associated with the Project/Site No., write it in this blank. For sites that are part of a larger investigation such as watershed, ambient, 303(d), TMDL or ecoregion, write the study name in this blank. This does not need to be filled out if there is no project or study name associated with the sample.

c. Station Number – The station ID number uniquely identifies the location where sample was collected. The station ID number must be completed. (For example PUNCH001.5GE. See Protocol B for assigning station numbers.)

d. County – Write the designated two-digit Tennessee County Code number, Tennessee County Number, (TN CO NO) in this blank. See Appendix A for a complete county list.

e. Description – Write a description of the location at which the sample was taken.

f. Stream Mile – Write the stream mile (or river mile) where the sample was collected.

g. Depth – Write the depth at which the water sample was collected if a discrete depth sampler was used to collect the sample. This line may be left blank for subsurface samples.

h. Matrix – Write the sample medium. (For example water, sediment or industrial waste.)

i. Collection Date – Write the date the sample was collected.

j. Time – Write the time the sample was collected recorded in military time (24-hour clock).

k. Sampler's Name – **Print legibly** the first and last name of the primary sampler.

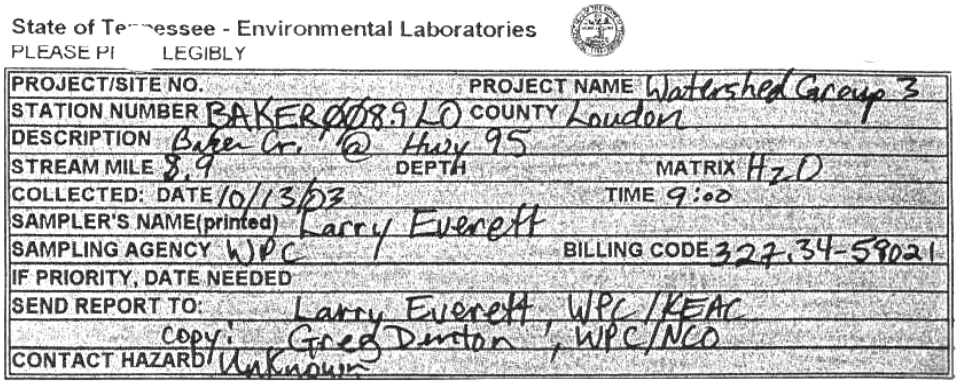
l. Sampling Agency – Write the agency for which the sample was collected. (For example WPC.)

m. Billing Code – Write the TDEC billing code or cost center assigned to various TDEC programs, for purchase of laboratory services. (For example 327.34-58 or 327.34-58021.)

n. If Priority, Date Needed – Only fill out if the analytical results are needed by a particular date such as a program-determined priority or health effect emergency. ASAP is never appropriate.

o. Send Report To – Write the person's name and address where the sample report is to be sent. Also, have all results sent to the manager of the Planning and Standards Section.

p. Contact Hazard – List any known hazards related to the sample (radiological, chemical, or biological). If there are no known hazards write unknown instead of none.


State of Tennessee - Environmental Laboratories
PLEASE PI LEGIBLY

PROJECT/SITE NO.	PROJECT NAME Watershed Group 3
STATION NUMBER BAKER008.9LO	COUNTY Loudon
DESCRIPTION Baker Cr. @ Hwy 95	
STREAM MILE 8.9	DEPTH MATRIX H2O
COLLECTED: DATE 10/13/03	TIME 9:00
SAMPLER'S NAME(printed) Larry Everett	
SAMPLING AGENCY WPC	BILLING CODE 327.34-58021
IF PRIORITY, DATE NEEDED	
SEND REPORT TO: Larry Everett, WPC/KEAC	
copy: Greg Denton, WPC/NCO	
CONTACT HAZARD Unknown	

Figure 3: Sample Request Form Header Information

2. Requested Analyses

Designate which analyses need to be performed on the sample by marking an "X" in the box left of the requested analysis (Protocol A) on the Sample Request Form(s) (Appendix A). Choose the needed analyses, but carefully consider cost. Write any special notations, such as requested dilution or low-level analysis, beside the needed analysis.

Consult the TMDL manager for needed analyses for TMDL development. Appendix C lists the needed analyses for metal, organic enrichment/DO, nutrient, and pathogen TMDL development. Minimally sample any 303(d) Listed waterbody for the cause(s) for which it was listed. Ecoregion, ambient, and watershed monitoring stations have a set parameter list (Table 6). Consult WPC annual Water Quality Monitoring and Planning Workplan for specific details on planned sampling objectives.

3. Field Determinations

Measure water parameters upstream of the chemical and bacteriological sample area, after the surface water samples are collected. Use calibrated instantaneous water parameter meters for all field measurements of water parameters (Protocol J). The readings for each parameter are recorded in the appropriate boxes labeled Field Determinations at the bottom left corner of the Chemical Request Form (Figure 4). Record all readings on the Chemical Request Sheet in the units specified on the sheet.

Conductivity must be recorded in micromhos per cubic centimeter (μmhos/cm^3), dissolved oxygen in parts per million (ppm), which is equivalent to milligram per liter (mg/l), and temperature in degrees Centigrade (^oC). If meter readings are in other units, record the exact readings in the field survey form or field book. Record the converted readings in the field determination box on the Chemical Request Sheet.

Write legibly to avoid errors in data interpretation. Since only one value can be entered in TDH's Laboratory Information Management System (LIMS), record the average of duplicate readings on the Chemical Request Form. Record all readings on the field survey sheet or field book. If the readings are not recorded on the Sample Request Form, send the readings directly to PAS to ensure readings will be entered in the Water Quality Database.

FIELD DETERMINATIONS	Temperature 13.11
pH 7.18	Chlorine, residual
Conductivity 108.3	Other
Dissolved Oxygen 9.69	

Figure 4: Sample Request Form Field Water Parameters

If, after the drift check, the meter was found to be off by more than 0.2 units for pH, temperature or dissolved oxygen or more than 10% for conductivity, write an N before the reading on the field survey sheet for all sites visited between the initial calibration and the drift check. The N designates questionable readings. Also, put an N before readings on the Chemical Request Form. If the Chemical Request Form has already been turned into the laboratory, fax the field data sheet to the central office and to appropriate laboratory to assure the readings are flagged as questionable when they are entered into the Water Quality Database.

4. Chain of Custody

TDEC's Office of General Counsel requires that the chain of custody (Figure 5) be completed for any sample that has the potential of being used in court, reviewed by the Water Quality Control Board, or involved in state hearings. Therefore, all samples are potentially legal and the integrity of the sample must be beyond question. It is required that the chain of custody be completely filled out and maintained in the project file. See Section II.C for additional information on the chain of custody.

The entire right column of TDH Environmental Laboratories' Chemical Request Form(s) is TDEC's official chain of custody. TDEC's Office of General Counsel has approved these forms. Currently these forms are in the process of being revised (see 5 for additional information). If using a TDEC contract laboratory other than TDH Environmental Laboratory, a separate chain of custody must be completed (Appendix A).

a. Chain of Custody (Required)

(1). Collected by – Sign the first line (first and last name) followed by the date and military time of collection.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived each time the sample changes hands. There are three correct options for completing this section:

(a) If the sample is delivered directly to the laboratory, write the lab's name and/or the name of the lab personnel who received the sample in this blank.
(b) If another staff member takes custody of the sample, write their name in this blank.
(c) If a mail, bus, or courier service is used to transport the samples to the laboratory, write the transportation service's name in this blank. The shipping receipt becomes part of the chain of custody documentation and must remain with the chain of custody paperwork.

(2). Received by – If the sample is transferred to someone else for delivery to the laboratory, including mail, bus, courier service, or TDEC staff, the recipient must sign their first and last name followed by the date and military time of receipt of the sample.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived. See (1).

(3). Received by – If the recipient of the sample gives the sample to a third person for transport to the laboratory, the receiver must sign their first and last name on this line and fill in the date and military time of receipt of the sample.

Delivered to - Write the name of the person or place where the sample was delivered and the date and military time it arrived. See (1).

(4). Received in Lab by – The person in the lab who receives the sample signs their full name followed by the date and military time the sample was received in the lab.

Logged in by – The person in the laboratory who logs in the sample signs their full name followed by the date and military time the sample is logged in.

b. Chain of Custody Additional Information (Required)

(1). Approximate volume of sample - Write the approximate quantity of all samples collected.

(2). Nearest town or city – Write the name of the nearest town to the collection point.

(3). Others present at collection – List all people (other than the sampler) present when the sample was collected.

(4). Number of other samples collected at same time at this point – Write the total number of additional bacteriological, chemical, biological, algal, or fish samples collected at this station during this sampling event. All analyses requested on the same Sample Request Form are considered one sample. For example, if bacteriological, routine, nutrient, and metals were the only bottles filled at a given site and the Inorganic Analysis Sample Request Form is the only form completed then these bottles are all considered the same sample. However, if organic volatile and biological samples were also collected at the same time the answer would be two additional samples.

(5). Field collection procedure, handling and/or preservation of this sample – If this WPC SOP was followed, write WPC SOP in this line. Denote any deviation from WPC protocol here.

(6). Mode of transportation to lab – Record the sample's method of transport to the laboratory (i.e. State vehicle, Greyhound bus, courier etc).

(7). Sample/cooler sealed by – Sign full name after the cooler has been sealed with a signed and dated custody seal.

(8). Date sample/cooler sealed – Write the date the sample or cooler was sealed with a signed and dated custody seal.

(9). Remarks – Write any special notations here.

Inorganic Analysis

Laboratory Number

Branch Lab Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by Jug Lugger
   Date 08/04/03 Time 11:35
   Delivered to Central Lab
   Date 08/04/03 Time 1435
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by Joe Logsdon
   Date 08/04/03 Time 1435
   Logged in by Joe Logsdon
   Date 08/04/03 Time 1535

Additional Information

1. Approximate volume of sample 1.5 gallons
2. Nearest town or city Murfreesboro, TN
3. Others present at collection Quincy Canwade
4. Number of other samples collected at same time at this point -0
5. Field collection procedure, handling and/or preservation of this sample - WPC SOP
6. Mode of transportation to lab - State Vehicle
7. Sample sealed by Jug Lugger
8. Date sample sealed 08/04/03
9. Remarks

RDA 1627

Figure 5: Sample Request Form Chain of Custody

5. Revised Chain of Custody

Currently the chain of custody form is in process of being revised (Figure 6). The primary change to the form is to trace the custody of the sample if it is transferred to another laboratory for analyses. Until the new forms are printed, either form may be used. However, it is preferred that the revised form be completed if nutrient, mercury or organic samples are delivered to the TDH branch laboratories since these are transferred to TDH central laboratory for analyses.

The only revision made to the top portion of the chain of custody was that the second received by and delivered section was removed. The additional information was extensively revised to expedite the completion of this section of the form. The same information as in the previous chain of custody form is included with the most likely answers listed so a check mark may be placed beside the appropriate answer. These changes should allow for quicker and easier completion of this section.

The final section, the gray shaded area at the bottom of the chain of custody is for lab use only. It is to be completed by the laboratory if a portion of the sample is to be transferred to another lab for analyses. For example, if samples are delivered to a TDH branch lab, nutrient, mercury, or organic bottles will be transferred to TDH central lab for analyses.

If completing the revised chain of custody, fill out the entire white portion and write legibly.

a. Chain of Custody (Required)

(1). Collected by – Sign the first line (first and last name) followed by the date and military time of collection.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived each time the sample changes hands. There are three correct options for completing this section:

(a) If the sample is delivered directly to the laboratory, write the lab's name and/or the name of the lab personnel who received the sample in this blank.
(b) If another staff member takes custody of the sample, write their name in this blank.
(c) If a mail, bus, or courier service is used to transport the samples to the laboratory, write the transportation service's name in this blank. The shipping receipt becomes part of the chain of custody documentation and must remain with the chain of custody paperwork.

(2). Received by – If the sample is transferred to someone else for delivery to the laboratory, including mail, bus, courier service, or TDEC staff, the recipient must sign their first and last name followed by the date and military time of receipt of the sample.

Delivered to – Write the name of the person or place where the sample was delivered and the date and military time it arrived. See (1).

(3). Received in Lab by – The person in the lab who receives the sample signs their full name followed by the date and military time the sample was received in the lab.

Logged in by – The person in the laboratory who logs in the sample signs their full name followed by the date and military time the sample is logged in.

b. Chain of Custody Additional Information (Required)

(1). Number (No.) of Bottles – Write the number of bottles collected.
Approximate total volume – Write the approximate collective volume of all bottles. Place a check mark beside each bottle collected at this time at this site.

(2). Others present at collection – Write the names and organization of other people present when the sample was collected. If no one else was there when the samples were collected check the none box. If more than two additional people were present write their names under remarks.

(3). Other samples collected – Place a check mark beside other samples that were collected at the same site at this time. If a sample besides those listed was collected, check others and describe.

(4). Field collection procedure, handling and/or preservation of this sample – If this WPC QS-SOP was followed to collect the sample place a check in this box. If the WPC QS-SOP was followed but deviations were inevitable, document changes under remarks. If another procedure was followed, describe it in the blank. Use additional sheets if needed to document deviations and attach to chain of custody.

(5). Mode of transportation to the lab – If the sample is delivered via a state vehicle place a check in the state vehicle box. If another means is used to transport the sample, mark other and describe.

(6). Sample sealed by – The person who seals the sample signs their full name on this line and dates when the sample was sealed.

(7). Remarks – Write any special notations or remarks on these lines.

c. Lab Use Only-Spilt Sample Transfer Record – This section is to be completed by the laboratory if samples are transferred to a different laboratory for some of the analyses.

Lab Log Number	
CHAIN OF CUSTODY	
Only one chain of custody form is required per sample set or point (if all collected at the same time)	
1. Collected by	
Date	Time
Delivered to	
Date	Time
2. Received by	
Date	Time
Delivered to	
Date	Time
3. Received in Lab by	
Date	Time
Logged in by	
Date	Time
ADDITIONAL INFORMATION	
1. No. of Bottles____ Approximate total volume _____ Bact. □ Routine □ Nutrient □ Metals □ Other □ ____	
2. Others present at collection None □	
Name: Org.	
Name: Org.	
3. Other samples collected: Inorganic □ Org. Extr. □ Org. Vol. □ Biological □ Other □ _____	
4. Field collection procedure, handling and/or preservation of this sample WPC QS-SOP □ Other □ _____	
5. Mode of transportation to lab State Vehicle □ Other □ _____	
6. Sample sealed by_____ Date _____	
7. Remarks	
Lab Use Only-Split Sample Transfer Record	
To: Nashville Lab (N)□ or other lab _____	
Total No. Bottles ____ Total Volume _____	
Nutrient □ Mercury □ Other _____	
1. Transferred by	
Date	Time
2. Delivered to	
Date	Time
Received by	
Date	Time
3. Log verified by	
Date	Time

Figure 6. Revised Chain of Custody

Protocol J – Instantaneous Field Parameters

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

Measure dissolved oxygen, pH, temperature and conductivity at each chemical or bacteriological monitoring station after samples are collected and before flow is measured or macroinvertebrates samples are collected. Place the probe upstream of where surface water samples were collected. Allow readings to equilibrate before recording measurements. Record the average of any duplicate readings on the Chemical Request Form under Field Determinations. Document all duplicate readings on the field survey sheet or in the field book.

Label all meters as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a distinct identifying designation, (i.e. letter or a portion of the serial number) for calibration, maintenance, and deployment records. Mark each meter with this designation. Record the meter's ID number on the Field Survey Sheet. Multi-probe or individual meters meeting the following minimum specifications may be used (Table 9).

Table 9: Instantaneous Probe Minimum Specifications

Parameter	Range	Accuracy	Resolution
Temperature	-5 ^{o}C to 40 ^{o}C	+/- 0.15 ^{o}C	0.01 ^{o}C
Specific Conductivity	0 to 2000 umhos/cm	+/- 1% of reading	4 digits
pH	0 to 14 units	+/- 0.2 units	0.01 units
Dissolved Oxygen	0 to 20 mg/L	+/- 0.2 mg/L	0.01 mg/L

1. **Calibrate Meter(s)** - At the beginning of each day, in the EAC lab, calibrate meter(s) for all parameters that will be measured, following the manufacturer's instructions. (For overnight trips, meters may be calibrated at the beginning of each sampling trip not to exceed 5 days.) If probes are factory calibrated, check readings against the appropriate standards to ensure the calibration is still accurate. Maintain calibration SOPs for each type and/or brand of meter. Keep all calibration records in a bound logbook (Figure 7). Include the date, meter designation, project name/number, initials of calibrator, parameter, standards used, meter reading, and adjustments. Also, record routine maintenance and repairs in the logbook.

   One means of calibrating temperature is to place an ASTM thermometer in a container of room temperature water large enough to submerge the temperature probe. To calibrate the probe, place the meter in the water bath and allow it to equilibrate then compare the probe's reading to the thermometer's reading and adjust the probe's temperature as necessary. Coordinate with TDH laboratory to include the ASTM thermometer in their annual thermometer calibration check against the ASTM certified thermometer.

EAC Meter Calibration Log

Date	Meter	Project	Init.	Parameter	Standard	Reading	Adj	Comments
3/6/02	YSI-A	Davis Ck	JEB	Conductivity	142	120	142	Cleaned contacts
3/6/02	YSI-A	Davis Ck	JEB	Conductivity	142	140	NA	Drift Check

Figure 7: Meter Calibration Log

2. **Air Calibrate DO Probe** – At the site, air calibrate the DO probe if DO percent saturation is to be measured and the barometric pressure (or elevation) has changed significantly. "After calibration, changes in barometric pressure do not affect concentration readings (i.e. … parts per million measurements), but do affect percent saturation readings" (Hydrolab, TechNote # 203). DO may also be determined using the Winkler method. Properly dispose of all reagents.

3. **Probe Placement** - Measure water parameter readings after collecting chemical and bacteriological samples and before measuring flow or collecting other samples (i.e. macroinvertebrate, algae). Turn on the meter(s) and make sure the DO stirrer is activated. Carefully place the meter(s) in the thalweg upstream of the chemical and bacteriological sampling area. Suspend the probe(s) in the water column so it does not touch the bottom. If the water is too shallow to suspend the meter(s), carefully lay it on its side on firm substrate (preferably rock). Do not allow the probe(s) to sink into soft substrate.

   Stand downstream of the probe, being careful not to disturb the substrate in the area of the probe(s). Allow enough time for each reading to stabilize before it is recorded. Depending on the meter, it may take a couple of minutes for dissolved oxygen to equilibrate. Record initial readings in the field notebook or the field survey form. The multi-parameter probe may also be placed a bucket filled with surface water and allowed to equilibrate. Rinse the bucket and probe twice with surface water before placing probe in the bucket of water.

4. **Duplicate Readings** - Take duplicate readings at each site. If time is a constraint, short sample holding times or darkness, duplicate readings may be reduced to the first and last site each day. To take a duplicate reading, lift the probe completely out of the water, wait for the readings to change then return it to the original location or slightly upstream if the sediment was disturbed. Allow the meter to equilibrate before recording readings. If the readings are off by more than 0.2 units (or 10% for conductivity), repeat the procedure until reproducible results are obtained. Record duplicate readings in the field notebook or the field survey form.

For water parameters collected with a bucket from a bridge of pier, dump the water from the first sample and refill the bucket with sample water before taking duplicate readings. Place the probe in the bucket and allow it to equilibrate before recording water parameter readings.

5. **Record Field Parameters** – Document the field parameters in the field determination boxes at the bottom left of the Sample Request Forms (Appendix A). If duplicates were taken, record the average of the acceptable duplicate readings. Conductivity must be recorded in umhos/cm^3, dissolved oxygen in ppm (mg/l), temperature in ^oC. If meter readings are in other units, record the exact readings in the field survey form or field book and record the converted readings in the field determination box on the Chemical Request Sheet.

6. **Drift Check** – Without post-calibration checks it cannot be demonstrated that water parameter readings are accurate. At the EAC lab, perform a drift check on each meter at the end of the day (or at the end of the trip on multiple night trips) and record results in the logbook (Figure 6). To check and make sure the probes have maintained their calibration, compare the probes readings against the appropriate pH, DO, conductivity and temperature standards, but do not adjust the calibration. If the meter's calibration is off by more than 0.2 for pH, DO, or temperature or more than 10% for conductivity, all readings between the initial calibration and the drift check must be marked as questionable (N). On stream survey sheets and Chemical Request Forms, precede all questionable readings with an N (questionable data). If Chemical Request Forms have already been submitted to TDH Environmental Laboratory, notify the Planning and Standards Section in writing (e-mail or fax) of questionable readings so they may be noted in the Water Quality Database.

Protocol K – Continuous Monitoring Field Parameters

Sampler

Adapted from U.S. Environmental Protection Agency. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, GA.

Some sampling objectives will require continuous monitoring of field parameters to document daily fluctuations. Continuous monitoring multi-parameter probes log water quality parameters at regular intervals for up to several months. Current studies suggest that probes should be deployed for at least 2 weeks to accurately gauge water parameter fluctuations. The length of deployment will depend on the study objectives. Often diurnal probes are used to monitor water conditions in the low flow months during late summer and early fall. Continuous monitoring probes meeting the following specifications may be used (Table 10).

Table 10: Continuous Monitoring Probe Minimum Specifications

Parameter	Range	Accuracy	Resolution
Temperature	0°C to 50 °C	+/- 0.2 °C	0.01 °C
Specific Conductivity	0 to maximum study requirements umhos/cm	+/- 1% of full scale	0.01 µS (>9,000) 0.1 µS (>10,000)
pH	0 to 14 units	+/- 0.2 units	0.01 units
Dissolved Oxygen	0 to 20 ppm	+/- 0.3 ppm	0.01 ppm

The continuous monitoring meter must be completely submerged in water throughout the study to record water parameters. At least 6 inches of water are required to submerge the probe. To produce manageable data, it is recommended that the probe be set to measure water parameter readings no more frequently than every 30 minutes. The sensors are very fragile, so be careful with the probe, especially when the sensor end cover is off for cleaning or maintenance.

Label all meters as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a distinct identifying number (i.e. serial number, letter, or number) for calibration, maintenance, and deployment records. Mark each meter with this designation.

1. **Pre-calibration Check** – Many continuous monitoring multi-parameter probes are factory calibrated. It is necessary to check the meter's calibration to prove the accuracy has not drifted. The morning of the deployment, at the EAC lab, check the meter's calibration, following manufacturer's directions. Maintain calibration and maintenance SOPs for each model and/or brand of meter. Keep all calibration check records in a bound logbook (Figure 6). Include the date, meter identification number, project name or number, initials of calibrator, parameter, standards used, meter reading, and adjustments. Also, record any maintenance or repairs in the logbook.

2. **Initiate Logging –** Either in the EAC office or at the sampling site, follow manufacturer's instructions to connect the continuous monitoring probe to a programmed computer with the sensor cable. Follow the manufacturer's instructions to program the logger and turn on the probe. Change the file name to the Station ID. Check the time, date on the probe, and reset if necessary. Set the probe to record water parameters at regular time intervals according to study needs. Intervals no more frequent than every 30-minutes are recommended to produce a manageable data set and preserve battery life. After the probe has been programmed and the logger has been started, disconnect the sensor cable and prepare the sensors for deployment following the manufacturer's instructions.

3. **Probe Location** - To accurately measure water conditions choose an area of even, non-turbulent flow in which the probe will remain submerged even if the water recedes. At least six continuous inches of water are required for the sensors to read the water parameters accurately. If possible, to avoid vandalism, place the probe in an area out of sight from bridges and roads.

   To check for maximum diurnal DO fluctuations associated with algae, secure the meter in an area with limited canopy cover. Be aware that if the probe is secured in direct sunlight, the daytime temperatures recorded may be higher than the actual water temperature due to radiant heating. If the study objective is to check diurnal DO swings in the most productive macroinvertebrate habitats, secure the probe in a canopied area. Avoid placing probe in a location that will receive full force of the floodwaters during storm activity (i.e. outside of bends, or bottleneck in streams).

4. **Probe Deployment –** Anchor the probe so it will remain stationary even if high water becomes a problem. Any means of securing the probe may be used. In streams with firm substrate, but not bedrock, a good way to secure the probe is to drive a rebar stake into the streambed and attach the sensor to the rebar with stainless steel cable. In bedrock substrate, stabilize the probe with a stainless steel cable or chain attached to a tree root, or boulder.

   Streams with silt and sand substrate pose an especially difficult challenge to avoid burying the probe in sediment. One solution that has been found is to place a concrete block on top of a wooden board and then attach the probe to the top of the concrete block. Another deployment method that works well in deeper waters is to attach the probe securely to a large float such as a boogie board. Then cable or chain the probe to a stable anchor point on the bank and to a weight to keep the floating probe in the channel.

   After the probe is securely anchored, camouflage the body of the probe with rocks and branches, but do not cover the sensor end of the probe. Log the probe deployment in the field log (Figure 8) and make careful notes and drawings about where the probe is located. In several weeks, it may be difficult to remember where the probe was placed. It is possible someone else will need to retrieve the probe.

Continuous Monitoring Probe Field Deployment Log

Diurnal Field Log								
Logger Set Out					**Logger Retrieved**			
Station ID	**Probe#**	**Date**	**Time**	**Init.**	**Date**	**Time**	**Init.**	**Comments**
JONES000.1DA	B	7/07/03	0900	JRS	7/21/03	0830	JRS	Lots Algae

Figure 8: Diurnal Field Log

5. **QC Probe Readings –** At 10 percent of the diurnal monitoring sites, anchor a second continuous monitoring probe beside the first to serve as quality control. (See Section II for additional QC information.)

6. **Probe Retrieval** – After the probe has been deployed the designated time, return to the site where the probe is anchored. Note the probe's location and condition. Carefully remove the probe from its anchor and stow it on the bank. Then retrieve the probe anchoring system and prepare the probe sensor for transport per manufacturer's instructions.

   Document probe condition on retrieval, and view readings with caution if the probe was covered in sediment or algae when it was retrieved. Disregard any questionable readings. Usually, the DO will drop markedly when the probe becomes buried. If the probe is not in the same location it was left make careful notes as to where the probe was found and its condition and view the readings with caution. Mark all paperwork with N for uncertain of results.

7. **Download Data** – Connect the continuous monitoring probe to the computer via the sensor cable. At the site, open the probe program on the laptop and turn the data logger off. If the probe will be redeployed immediately, download the recorded data onto the laptop computer. Data may be downloaded in transit to the next site. Back-up the data on a floppy disk or CD. If the probe will be returned to the office before it is used again, the data may be downloaded to a programmed desktop computer.

8. **Post-Calibration Check** – A post-calibration drift check must be performed on the continuous monitoring multi-parameter probes to verify that the calibration has not drifted. Record the post calibration check in a bound logbook (Figure 6). Include the date, meter identification number, project name/number, initials of person performing the calibration, parameter, standards used, meter reading, and adjustments in the logbook. Also, record any maintenance or repairs in the logbook. Notify your supervisor if readings are off by more than 10% and mark all associated paperwork with N (uncertain of results).

9. **Clean Probe** – After the post calibration check, clean the sensors very carefully. (The sensors are fragile.) Follow the manufacturer's instructions for cleaning, maintenance, or repairs of the sensors.

10. **Data Interpretation** – Due to set up time and the reading delay, disregard the initial readings. Determine which readings reflect water quality and disregard prior readings. Review readings for all parameters and check for anomalies. It is possible for the water level to drop and rise back up during the time of deployment. If the probe was not in the same location it was left, carefully review data to determine if it has been removed from the water. Retain original files.

Protocol L – Flow Measurement

Sampler

Adapted from Buchanan, Thomas J. and William P. Somers. 1976. Chapter A8, Discharge Measurements at Gaging Station, Book 3, Applications of Hydraulic, in *Techniques for Water-Resource Investigation*. United States Geological Survey. Washington, D.C.

The accurate measurement of flow is essential to most water pollution control activities. Flow measurement is required for TMDL development (Appendix C) and NPDES monitoring. It is also important for enforcement cases. If holding times are a constraint, flow may be measured later the same day provided there has been no precipitation or change in the flow.

If possible, in wadeable waters, measure the flow with an electromagnetic current meter after bacteriological and chemical samples are collected, physical water parameters are measured and before leaving the site. In waters too shallow for use of an electromagnetic current meter or too deep to safely wade, flow may be estimated. For non-wadeable waterbodies, vertical-axis rotor cup type meters may also be used to measure flow. Follow manufacture's instructions for use, calibration, and maintenance of all flow meters. Record all measurements in tenths of feet.

A. Flow Measurement with Electromagnetic Current Meter

Label each flow meter as property of the State of Tennessee, Department of Environment and Conservation. Assign each meter a unique identification letter or number (i.e. A, B, 1,2, or a portion of the serial number). Mark each meter with this meter identification number. Electromagnetic current meters meeting the following specifications (Table 11) may be used:

Table 11: Electromagnetic Flow Meter Minimum Specifications

Range	Accuracy	Resolution
-0.5 to 20 ft./sec.	+/- 2% of the reading + Zero stability (+/- 0.05 ft./sec.)	0.1 ft./sec.

1. **Calibrate Meter** - Calibrate the flow meter at the EAC lab, per manufacturer's instructions at the beginning of each day of use. For overnight trips, meters may be calibrated at the beginning of each sampling trip not to exceed 5 days. Maintain calibration and maintenance SOPs for each brand and/or model of flow meter. Keep all calibration records in a logbook. Include date, meter identification number, project name or number, initials of calibrator, flow measurement, adjustments, and maintenance or repair records in the logbook. Check to be certain the meter is reading in feet per seconds.

2. **Select Transect -** At the site, select a safely wadeable transect to measure velocity. If possible, the transect should be in a straight area with measurable linear flow. The water surface should be flat, not riffling, with no large obstructions to disrupt the smooth current. The ideal (usually not possible) would be a flat, straight channel with a linear current at an even depth and velocity across the whole channel.

   One of the best areas to consider is a run just before a riffle. Avoid braided areas next to large, wet gravel bars, stagnant water, eddies, and bridges. Some channel modifications may make a more uniform channel and be appropriate for measuring flow. Stretch a surveyor's tape (English measurements, marked in tenths of feet), on the selected transect from the left descending bank (LDB) to the right descending bank (RDB) perpendicular to the flow direction. Clamp the ends of the surveyor's tape at the top of each bank to trees and/or stakes. Make sure the surveyor's tape is straight, taut, and close to the water at an even height across the creek.

   Record the meter identification number and document where flow measurements were taken. Remove large stones or logs that may interfere with flow and the placement of the wading rod before flow is measured.

3. **Measure Flow -** Attach the sensor probe to the sensor mount on the wading rod and the sensor cable to the display unit. Turn on the flow meter and make sure it is reading in feet/second (Ft/S). Record all flow information on the Field Flow Measurement Sheet (Appendix A) or in a field notebook.

   a. **Record Tape Reading** – Record the tape measurement (in tenths of feet) at the left edge of water (LEW). Make the first velocity reading as soon as the water depth is adequate to cover the sensor. Place the wading rod's weighted base flat on the streambed below the surveyors tape and hold it vertically (make sure it is straight). Record the precise tape measurement in the tape-reading column located on the left column (tape reading) of field flow measurement sheet or in the field book. Actual distance measures can be calculated at the office.

   b. **Measure Water Depth** - Follow the manufacturer's instructions for measuring water depth and placing the sensor at the proper depth in the water column. Record the water depth (in tenths of feet) at this location in the depth column of field flow measurement sheet or in the field book.

   c. **Measure Velocity –** Adjust the sensor on the wading rod to the proper water depth and point the sensor perpendicular to transect tape. If the water is less than 2.5 feet deep, measure velocity at 0.6 of the total depth. For water deeper than 2.5 feet, measure velocity at both 0.2 and 0.8 of the total water depth and average the reading. Stand downstream and slightly to one side so as not to affect the flow of the current. Allow the readings to equilibrate and then record the average velocity reading in the velocity column on the field flow measurement sheet or in the field book.

d. Repeat Velocity Measurement – To choose the appropriate spacing of the velocity readings consider the entire stream flow. Ideally, there should be no more than 5 to 10 percent of the total stream flow between each velocity reading. In areas with faster flow, readings will be spaced closer together. Velocity readings may be spaced further apart in areas with slower flow. Readings do not have to be at even increments, however it is important to accurately record distances and depths.

Record the tape reading, water depth and velocity on the next line of the field flow measurement sheet or field notebook. Repeat this procedure for 20 – 30 readings across the stream channel. For streams less than 5 feet wide, take readings at six-inch intervals. Take the final reading near the right edge of water (REW) at the last place the water is deep enough to cover the sensor. Record the tape reading at the right edge of water (REW). Use additional sheets if more than 30 readings are necessary.

4. QC Flow Measurement - At 10 percent of the sites where flow is measured, take a second flow reading in the same transect. Measure QC flow on the same day as the original flow is measured.

If holding times are a constraint, flow and/or QC flow measurements may be taken later the same day if there has been no precipitation or change in flow. After flow has been calculated, if there is more than 10 percent difference between the original and QC flow calculations, designate both flows with an N for uncertainty of accuracy of measurement.

5. Post-Calibration Check – Check the flow meter calibration at the end of each day (or at the end of overnight trips) in the EAC lab, according to manufacturer's instruction. Do not clean the sensor before performing post trip calibration check. Record the post trip calibration check in logbook. Flag the results with an N (for questionable) if the reading is off by more than +/- 0.05 Ft/S. After the post calibration drift check, adjust the calibration as needed following manufacturer's instructions.

6. Calculate Flow - An excel spreadsheet can quickly and accurately calculate total flow. An example of the flow measurement sheet with excel formulas is included in Appendix A. Contact the Planning and Standards Section if an electronic version of this flow calculation spreadsheet is needed. Any method that accurately calculates flow is acceptable.

Translate the tape readings from the field flow measurement sheet to distance from the LDB on the flow measurement sheet. Do not round off tape readings, water depth, or velocity readings. After flow has been calculated, round the total flow to the appropriate significant digit (generally 2 decimal places).

To calculate total flow of the stream or river use the following formula:

1. Determine the cell width. Each cell width is composed of half of the distance between the previous and the next flow reading, $(W_c-W_a)/2$.
2. Determine the cell area. The cell area is made up of cell width, $(W_c-W_a)/2$, multiplied by the center depth measurement (D_b) of each cell.
3. Calculate cell flow by multiply the cell area, $D_b[(W_c-W_a)/2]$, times the center velocity reading (V_b) of each cell.
4. Sum all the cell flow readings, $D_b[(W_c-W_a)/2]V_b$, to calculate total flow of the stream or river. This value is the total flow of the stream or river in cubic feet per second (CFS).

$$\Sigma = D_1[(W_2-W_1)/2]V_1 + D_2[(W_3-W_1)/2]V_2 + D_3[(W_4-W_2)/2]V_3 +\ldots+ D_{25}[(W_{25}-W_{24})/2]V_{25}$$

7. **QC Date Entry** – Have the QC Quality Team Member (Section II.A) or their designee QC data entry and flow calculation before reporting the flow data.

B. Flow Estimation Float Method

In waters too shallow for use of a current meter or too deep to safely wade, flow may be estimated by the float method. The only items needed to estimate flow are a watch (with seconds reading) or stopwatch, a measurement tool such as a yardstick or tape measure (english units), and something that floats like an orange, cork or piece of wood. Do not use non-biodegradable objects such as plastic bottles.

Use the following steps to estimate flow:

1. Measure and record the stream width and the stream depth in at least three places. Average the stream depth readings.
2. Multiply the average depth times the stream width to estimate the cross-sectional area.
3. To estimate water velocity, mark a given distance and time how long it takes the floating object to float the measured distance.
4. Repeat the velocity estimation at least three times and average the readings to determine mean velocity.
5. Since water flows fastest at the surface, multiply the mean velocity by 0.8.
6. To estimate flow, multiply the mean velocity (times 0.8) times the cross-sectional area (average depth times width). Record flow in cubic feet per second (CFS).

Estimated Flow = [Mean Velocity (0.8)] (Avg. Depth) (Width)

C. Flow Estimation Bucket Method

In very small waterways, too small for an object to float, a graduated bucket or cylinder and a watch (with second readings) or a stopwatch may be used to estimate flow. A small temporary dam must be built to channel all flow to a weir or pipe. Capture all of the flow into a graduated bucket or cylinder over a given period of time and measure the amount of water captured. For example if 1.7 liter were captured in 10 seconds, the flow would be 0.17L/Sec. Repeat this measurement at least three times and report the average as the estimated flow.

D. Staff Gage Flow Measurement

If a staff gage is installed at a site, record the water height on the gage. Later plot the staff height on the established flow curve to determine flow or contact the USGS office responsible for the gage request the flow in cubic feet per second for the corresponding gage height. See USGS protocol for methods and additional information (Buchanan and Somers, 1976).

Protocol M – Bacteriological (Pathogen) Analyses

Sampler or Designee

Adapted from American Public Health Association, American Waterworks Association, Water Environment Federation. 1995. *19th Edition, Standard Methods for Examination of Water and Wastewater.* American Public Health Association. Washington, D.C.

Due to short holding times and long distances to the laboratory, it a may be more convenient for some EACs to analyze the bacteriological water samples themselves. Specialized equipment is required to analyze bacteriological samples. EPA has approved the use of IDEXX Quanti-Tray®/2000 for analyzing water samples for total coliform and *E. coli* testing.

The Quanti-Tray®/2000 method detects the presence of enzymes produced by total coliform bacteria and *E. coli*. Enzymes produced by total coliform will hydrolyze the substrate and produce a yellow color. If enzymes produced by *E. coli* bacteria are present, they will hydrolyze the substrate and cause the sample to fluoresce under a long-wavelength ultraviolet light.

The media used in this test must be purchased from a commercially available source. Store Colilert media at room temperature and protect it from light. Colilert reagent media have a shelf life of one year. Do not use expired or discolored reagents. Some media lots have been found to autofluoresce. So, whenever a new lot is received, check it for fluorescence under the 366-nm ultraviolet light with a 6-watt bulb and do not use if any florescence is present.

A. Assign Pathogen Log Number

Log each pathogen sample analyzed at the EAC. Assign a discrete log number to each individual pathogen or bacteriological quality control sample. This will be a unique nine-digit number (i.e. CP0305001) determined in the following manner:

- The first digit represents the office that analyzes the sample (Table 12). The second digit (P) denotes a pathogen (bacteriological) sample.

  Table 12: Pathogen Log Number Prefixes

Office Abbreviation	EAC Name	Office Abbreviation	EAC Name
CP	Chattanooga EAC	JP	Jackson EAC
LP	Columbia EAC	KP	Knoxville EAC
VP	Cookeville EAC	MP	Memphis EAC
HP	Johnson City EAC	NP	Nashville EAC

- The third and fourth digits represent the year sampled (03 = 2003).

- The fifth and sixth digits represent the month sampled (05 = May).

- The last three digits represent a consecutive number for the number of samples collected that month (001 = the first sample collected in May, 2003).

CP0305001 = the first pathogen sample logged in Chattanooga EAC in May, 2003.

B. Log Pathogen Sample

Maintain a logbook of all bacteriological and quality control samples analyzed at the EAC (Figure 9). The logbook must minimally contain the following information:

- Date sample collected
- Time sample collected
- Station ID number or appropriate QC designation
- EAC pathogen log number
- Media reagent lot number
- If sample is a QC
- Initials of the person who inoculated the sample
- Date sample was inoculated and placed in the incubator
- Time sample was inoculated
- Temperature of incubator
- Date sample was removed from the incubator and analyzed
- Time sample was analyzed
- Initials of the person who read the test results (analyzed the sample)
- Number of large and small wells that turned a yellow color equal to or darker than the comparator
- Number of large and small wells that fluoresce under a UV lamp equal to or darker than the comparator
- Record the most probable number Total coliform results from the Quanti-Tray®/2000 MPN table (Table 13)
- Record the most probable number *E. coli* results from the Quanti-Tray®/2000 MPN table (Table 13)
- Record any comments, cautions, QC results or maintenance. Additional comments can be recorded on the following rows.

Pathogen Log

Col. Date	Col. Time	Station ID/ QC ID	EAC Pathogen Log #	Reagent lot #	QC	Inoc. Init.	Date Inoc.	Time inoc	Incub. temp. (^{o}C)	Anal. date	Anal. time	Anal. Init.	# yellow Lg/Sm wells (+Total Colif.)	# fluor. Lg/Sm wells (+ *E.coli*)	MPN Total Colif.	MPN *E.coli*	Comments/ Maintenance
5/29/03	0830	BAKER 008.9WA	HP0305001	472HY		JAL	5/29/03	1400	34.8	5/30/03	1405	JAL	46/48	26/40	533	101	
5/29/03	1000	BWAR 007.4HK	HP0305002	472HY		JAL	5/29/03	1410	34.8	5/30/03	1415	JAL	31/48	11/33	142	51	
5/29/03	1200	RIPLEY 000.1HK	HP0305003	472HY		JAL	5/29/03	1415	34.8	5/30/03	1425	JAL	49/44	49/31	1553	649	
6/02/03	0800	PUNCH 001.5GE	HP0306001	472HY		JAL	6/02/03	1330	35.2	6/03/03	1300	JAL	49/40	40/24	1120	140	
NA	NA	QC- *P. aerug.*	HP0306002	472HY	X	JAL	6/02/03	1340	35.2	6/03/03	1310	JAL	0/0	0/0	0	0	*P.aeruginosa* QC -PASS
NA	NA	QC-*K. pneum.*	HP0306003	472HY	X	JAL	6/02/03	1345	35.2	6/03/03	1315	JAL	49/36	0/0	866	0	*K.pneumoniae* QC-PASS
NA	NA	QC- *E. coli*	HP0306004	472HY	X	JAL	6/02/03	1350	35.2	6/03/03	1320	JAL	47/46	40/39	640	198	*E. coli* QC-PASS
NA	NA	QC- Quanti-Tray sealer	HP0306005	NA	X	JAL	6/02/03	1400	NA	6/02/03	1415	JAL	NA	NA	NA	NA	Quanti-Tray sealer QC-PASS

Figure 9: Pathogen Analyses Log

Follow manufacture's instructions for inoculation and interpretation of results.

C. Use of the Colilert 18 or 24 Method Quanti-Tray®/2000

1. Add reagent media to sample. Colilert snap pack reagents are sized for specific volumes of water. Measure the amount of sample water appropriate for the reagent pack. Open the snap pack of media reagent and pour it into the sample water. Place lid on the sterile container and shake it until completely dissolved. Allow any foam to subside before pouring.

2. Carefully pour sample reagent mixture into the Quanti-Tray® without touching the foil tab. Tap tray to remove air bubbles before sealing.

3. Seal Quanti-Tray® according to manufacture's instructions.

4. Incubate the sample at 35^{o}C +/- 0.5^{o}C for 18 or 24 hours, depending on the Colilert Method.

5. Read test results at 18 or 24 hours. There is a +4 hour period following the 18 or 24 hours incubation period within which the samples may be read.

    a. If no yellow color is observed, the test is negative for total coliform.

    b. If a yellow color lighter than the comparator yellow color is observed incubate the sample for an additional 4 hours, then check the color. If the color has intensified, the sample is positive. If it has not, the test is negative.

    c. If the sample has a yellow color equal to or greater than the comparator, the sample is positive for total coliform. Count the number of yellow large and small wells.

    d. Samples positive for total coliform can be checked for the presence of *E. coli* by placing the Quanti-Tray® in a 6-watt, 365 nm UV lamp and checking for fluorescence. If the fluorescence is equal to or greater than the comparator the sample is positive for *E. coli*. Count the number of large and small fluorescent wells.

6. To determine the coliform and *E. coli* density, compare the number of yellow and/or fluorescing wells to the Most Probable Number (MPN) table provided by the manufacture (Table 13).

Table 13: Quanti-Tray®/2000 Most Probable Number Table

IDEXX Quanti-Tray®/2000 MPN Table (per 100ml)

# Large Wells Positive	# Small Wells Positive																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	<1	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.1	15.1	16.1	17.1	18.1	19.1	20.2	21.2	22.2	23.3	24.3
1	1.0	2.0	3.0	4.0	5.0	6.0	7.1	8.1	9.1	10.1	11.1	12.1	13.2	14.2	15.2	16.2	17.3	18.3	19.3	20.4	21.4	22.4	23.5	24.5	25.6
2	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.2	10.2	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.7	24.8	25.8	26.9
3	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.5	17.6	18.6	19.7	20.8	21.8	22.9	23.9	25.0	26.1	27.1	28.2
4	4.1	5.2	6.2	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.6	16.7	17.8	18.8	19.9	21.0	22.0	23.1	24.2	25.3	26.3	27.4	28.5	29.6
5	5.2	6.3	7.3	8.4	9.4	10.5	11.5	12.6	13.7	14.7	15.8	16.9	17.9	19.0	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.7	28.8	29.9	31.0
6	6.3	7.4	8.4	9.5	10.6	11.6	12.7	13.8	14.9	16.0	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.9	28.0	29.1	30.2	31.3	32.4
7	7.5	8.5	9.6	10.7	11.8	12.8	13.9	15.0	16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1	28.3	29.4	30.5	31.6	32.8	33.9
8	8.6	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.1	25.2	26.3	27.4	28.6	29.7	30.8	32.0	33.1	34.3	35.4
9	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.6	18.7	19.8	20.9	22.0	23.2	24.3	25.4	26.6	27.7	28.9	30.0	31.2	32.3	33.5	34.6	35.8	37.0
10	11.0	12.1	13.2	14.4	15.5	16.6	17.7	18.9	20.0	21.1	22.3	23.4	24.6	25.7	26.9	28.0	29.2	30.3	31.5	32.7	33.8	35.0	36.2	37.4	38.6
11	12.2	13.4	14.5	15.6	16.8	17.9	19.1	20.2	21.4	22.5	23.7	24.8	26.0	27.2	28.3	29.5	30.7	31.9	33.0	34.2	35.4	36.6	37.8	39.0	40.2
12	13.5	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	23.9	25.1	26.3	27.5	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.0	38.2	39.5	40.7	41.9
13	14.8	16.0	17.1	18.3	19.5	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.5	38.7	39.9	41.2	42.4	43.6
14	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5	31.7	33.0	34.2	35.4	36.7	37.9	39.1	40.4	41.6	42.9	44.2	45.4
15	17.5	18.7	19.9	21.1	22.3	23.5	24.7	25.9	27.2	28.4	29.6	30.9	32.1	33.3	34.6	35.8	37.1	38.4	39.6	40.9	42.2	43.4	44.7	46.0	47.3
16	18.9	20.1	21.3	22.6	23.8	25.0	26.2	27.5	28.7	30.0	31.2	32.5	33.7	35.0	36.3	37.5	38.8	40.1	41.4	42.7	44.0	45.3	46.6	47.9	49.2
17	20.3	21.6	22.8	24.1	25.3	26.6	27.8	29.1	30.3	31.6	32.9	34.1	35.4	36.7	38.0	39.3	40.6	41.9	43.2	44.5	45.9	47.2	48.5	49.8	51.2
18	21.8	23.1	24.3	25.6	26.9	28.1	29.4	30.7	32.0	33.3	34.6	35.9	37.2	38.5	39.8	41.1	42.4	43.8	45.1	46.5	47.8	49.2	50.5	51.9	53.2
19	23.3	24.6	25.9	27.2	28.5	29.8	31.1	32.4	33.7	35.0	36.3	37.6	39.0	40.3	41.6	43.0	44.3	45.7	47.1	48.4	49.8	51.2	52.6	54.0	55.4
20	24.9	26.2	27.5	28.8	30.1	31.5	32.8	34.1	35.4	36.8	38.1	39.5	40.8	42.2	43.6	44.9	46.3	47.7	49.1	50.5	51.9	53.3	54.7	56.1	57.6
21	26.5	27.9	29.2	30.5	31.8	33.2	34.5	35.9	37.3	38.6	40.0	41.4	42.8	44.1	45.5	46.9	48.4	49.8	51.2	52.6	54.1	55.5	56.9	58.4	59.9
22	28.2	29.5	30.9	32.3	33.6	35.0	36.4	37.7	39.1	40.5	41.9	43.3	44.8	46.2	47.6	49.0	50.5	51.9	53.4	54.8	56.3	57.8	59.3	60.8	62.3
23	29.9	31.3	32.7	34.1	35.5	36.8	38.3	39.7	41.1	42.5	43.9	45.4	46.8	48.3	49.7	51.2	52.7	54.2	55.6	57.1	58.6	60.2	61.7	63.2	64.7
24	31.7	33.1	34.5	35.9	37.3	38.8	40.2	41.7	43.1	44.6	46.0	47.5	49.0	50.5	52.0	53.5	55.0	56.5	58.0	59.5	61.1	62.6	64.2	65.8	67.3
25	33.6	35.0	36.4	37.9	39.3	40.8	42.2	43.7	45.2	46.7	48.2	49.7	51.2	52.7	54.3	55.8	57.3	58.9	60.5	62.0	63.6	65.2	66.8	68.4	70.0
26	35.5	36.9	38.4	39.9	41.4	42.8	44.3	45.9	47.4	48.9	50.4	52.0	53.5	55.1	56.7	58.2	59.8	61.4	63.0	64.7	66.3	67.9	69.6	71.2	72.9
27	37.4	38.9	40.4	42.0	43.5	45.0	46.5	48.1	49.6	51.2	52.8	54.4	56.0	57.6	59.2	60.8	62.4	64.1	65.7	67.4	69.1	70.8	72.5	74.2	75.9
28	39.5	41.0	42.6	44.1	45.7	47.3	48.8	50.4	52.0	53.6	55.2	56.9	58.5	60.2	61.8	63.5	65.2	66.9	68.6	70.3	72.0	73.7	75.5	77.3	79.0
29	41.7	43.2	44.8	46.4	48.0	49.6	51.2	52.8	54.5	56.1	57.8	59.5	61.2	62.9	64.6	66.3	68.0	69.8	71.5	73.3	75.1	76.9	78.7	80.5	82.4
30	43.9	45.5	47.1	48.7	50.4	52.0	53.7	55.4	57.1	58.8	60.5	62.2	64.0	65.7	67.5	69.3	71.0	72.9	74.7	76.5	78.3	80.2	82.1	84.0	85.9
31	46.2	47.9	49.5	51.2	52.9	54.6	56.3	58.1	59.8	61.6	63.3	65.1	66.9	68.7	70.5	72.4	74.2	76.1	78.0	79.9	81.8	83.7	85.7	87.6	89.6
32	48.7	50.4	52.1	53.8	55.6	57.3	59.1	60.9	62.7	64.5	66.3	68.2	70.0	71.9	73.8	75.7	77.6	79.5	81.5	83.5	85.4	87.5	89.5	91.5	93.6
33	51.2	53.0	54.8	56.5	58.3	60.2	62.0	63.8	65.7	67.6	69.5	71.4	73.3	75.2	77.2	79.2	81.2	83.2	85.2	87.3	89.3	91.4	93.6	95.7	97.8
34	53.9	55.7	57.6	59.4	61.3	63.1	65.0	67.0	68.9	70.8	72.8	74.8	76.8	78.8	80.8	82.9	85.0	87.1	89.2	91.4	93.5	95.7	97.9	100.2	102.4
35	56.8	58.6	60.5	62.4	64.4	66.3	68.3	70.3	72.3	74.3	76.3	78.4	80.5	82.6	84.7	86.9	89.1	91.3	93.5	95.7	98.0	100.3	102.6	105.0	107.3
36	59.8	61.7	63.7	65.7	67.7	69.7	71.7	73.8	75.9	78.0	80.1	82.3	84.5	86.7	88.9	91.2	93.5	95.8	98.1	100.5	102.9	105.3	107.7	110.2	112.7
37	62.9	65.0	67.0	69.1	71.2	73.3	75.4	77.6	79.8	82.0	84.2	86.5	88.8	91.1	93.4	95.8	98.2	100.6	103.1	105.6	108.1	110.7	113.3	115.9	118.6
38	66.3	68.4	70.6	72.7	74.9	77.1	79.4	81.6	83.9	86.2	88.6	91.0	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.2	113.9	116.6	119.4	122.2	125.0
39	70.0	72.2	74.4	76.7	78.9	81.3	83.6	86.0	88.4	90.9	93.4	95.9	98.4	101.0	103.6	106.3	109.0	111.8	114.6	117.4	120.3	123.2	126.1	129.2	132.2
40	73.8	76.2	78.5	80.9	83.3	85.7	88.2	90.8	93.3	95.9	98.5	101.2	103.9	106.7	109.5	112.4	115.3	118.2	121.2	124.3	127.4	130.5	133.7	137.0	140.3
41	78.0	80.5	83.0	85.5	88.0	90.6	93.3	95.9	98.7	101.4	104.3	107.1	110.0	113.0	116.0	119.1	122.2	125.4	128.7	132.0	135.4	138.8	142.3	145.9	149.5
42	82.6	85.2	87.8	90.5	93.2	96.0	98.8	101.7	104.6	107.6	110.6	113.7	116.9	120.1	123.4	126.7	130.1	133.6	137.2	140.8	144.5	148.3	152.2	156.1	160.2
43	87.6	90.4	93.2	96.0	99.0	101.9	105.0	108.1	111.2	114.5	117.8	121.1	124.6	128.1	131.7	135.4	139.1	143.0	147.0	151.0	155.2	159.4	163.8	168.2	172.8
44	93.1	96.1	99.1	102.2	105.4	108.6	111.9	115.3	118.7	122.3	125.9	129.6	133.4	137.4	141.4	145.5	149.7	154.1	158.5	163.1	167.9	172.7	177.7	182.9	188.2
45	99.3	102.5	105.8	109.2	112.6	116.2	119.8	123.6	127.4	131.4	135.4	139.6	143.9	148.3	152.9	157.6	162.4	167.4	172.6	178.0	183.5	189.2	195.1	201.2	207.5
46	106.3	109.8	113.4	117.2	121.0	125.0	129.1	133.3	137.6	142.1	146.7	151.5	156.5	161.6	167.0	172.5	178.2	184.2	190.4	196.8	203.5	210.5	217.8	225.4	233.3
47	114.3	118.3	122.4	126.6	130.9	135.4	140.1	145.0	150.0	155.3	160.7	166.4	172.3	178.5	185.0	191.8	198.9	206.4	214.2	222.4	231.0	240.0	249.5	259.5	270.0
48	123.9	128.4	133.1	137.9	143.0	148.3	153.9	159.7	165.8	172.2	178.9	186.0	193.5	201.4	209.8	218.7	228.2	238.2	248.9	260.3	272.3	285.1	298.7	313.0	328.2
49	135.5	140.8	146.4	152.3	158.5	165.0	172.0	179.3	187.2	195.6	204.6	214.3	224.7	235.9	248.1	261.3	275.5	290.9	307.6	325.5	344.8	365.4	387.3	410.6	435.2

09-63235-01

Table 13 continued: Quanti-Tray®/2000 Most Probable Number Table

IDEXX Quanti-Tray®/2000 MPN Table *(per 100ml)*

# Large Wells Positive	# Small Wells Positive																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
0	25.3	26.4	27.4	28.4	29.5	30.5	31.5	32.6	33.6	34.7	35.7	36.8	37.8	38.9	40.0	41.0	42.1	43.1	44.2	45.3	46.3	47.4	48.5	49.5
1	26.6	27.7	28.7	29.8	30.8	31.9	32.9	34.0	35.0	36.1	37.2	38.2	39.3	40.4	41.4	42.5	43.6	44.7	45.7	46.8	47.9	49.0	50.1	51.2
2	27.9	29.0	30.0	31.1	32.2	33.2	34.3	35.4	36.5	37.5	38.6	39.7	40.8	41.9	43.0	44.0	45.1	46.2	47.3	48.4	49.5	50.6	51.7	52.8
3	29.3	30.4	31.4	32.5	33.6	34.7	35.8	36.8	37.9	39.0	40.1	41.2	42.3	43.4	44.5	45.6	46.7	47.8	48.9	50.0	51.2	52.3	53.4	54.5
4	30.7	31.8	32.8	33.9	35.0	36.1	37.2	38.3	39.4	40.5	41.6	42.8	43.9	45.0	46.1	47.2	48.3	49.5	50.6	51.7	52.9	54.0	55.1	56.3
5	32.1	33.2	34.3	35.4	36.5	37.6	38.7	39.9	41.0	42.1	43.2	44.4	45.5	46.6	47.7	48.9	50.0	51.2	52.3	53.5	54.6	55.8	56.9	58.1
6	33.5	34.7	35.8	36.9	38.0	39.2	40.3	41.4	42.6	43.7	44.8	46.0	47.1	48.3	49.4	50.6	51.7	52.9	54.1	55.2	56.4	57.6	58.7	59.9
7	35.0	36.2	37.3	38.4	39.6	40.7	41.9	43.0	44.2	45.3	46.5	47.7	48.8	50.0	51.2	52.3	53.5	54.7	55.9	57.1	58.3	59.4	60.6	61.8
8	36.6	37.7	38.9	40.0	41.2	42.3	43.5	44.7	45.9	47.0	48.2	49.4	50.6	51.8	53.0	54.1	55.3	56.5	57.7	59.0	60.2	61.4	62.6	63.8
9	38.1	39.3	40.5	41.6	42.8	44.0	45.2	46.4	47.6	48.8	50.0	51.2	52.4	53.6	54.8	56.0	57.2	58.4	59.7	60.9	62.1	63.4	64.6	65.8
10	39.7	40.9	42.1	43.3	44.5	45.7	46.9	48.1	49.3	50.6	51.8	53.0	54.2	55.5	56.7	57.9	59.2	60.4	61.7	62.9	64.2	65.4	66.7	67.9
11	41.4	42.6	43.8	45.0	46.3	47.5	48.7	49.9	51.2	52.4	53.7	54.9	56.1	57.4	58.6	59.9	61.2	62.4	63.7	65.0	66.3	67.5	68.8	70.1
12	43.1	44.3	45.6	46.8	48.1	49.3	50.6	51.8	53.1	54.3	55.6	56.8	58.1	59.4	60.7	62.0	63.2	64.5	65.8	67.1	68.4	69.7	71.0	72.4
13	44.9	46.1	47.4	48.6	49.9	51.2	52.5	53.7	55.0	56.3	57.6	58.9	60.2	61.5	62.8	64.1	65.4	66.7	68.0	69.3	70.7	72.0	73.3	74.7
14	46.7	48.0	49.3	50.5	51.8	53.1	54.4	55.7	57.0	58.3	59.6	60.9	62.3	63.6	64.9	66.3	67.6	68.9	70.3	71.6	73.0	74.4	75.7	77.1
15	48.6	49.9	51.2	52.5	53.8	55.1	56.4	57.8	59.1	60.4	61.8	63.1	64.5	65.8	67.2	68.5	69.9	71.3	72.6	74.0	75.4	76.8	78.2	79.6
16	50.5	51.8	53.2	54.5	55.8	57.2	58.5	59.9	61.2	62.6	64.0	65.3	66.7	68.1	69.5	70.9	72.3	73.7	75.1	76.5	77.9	79.3	80.8	82.2
17	52.5	53.9	55.2	56.6	58.0	59.3	60.7	62.1	63.5	64.9	66.3	67.7	69.1	70.5	71.9	73.3	74.8	76.2	77.6	79.1	80.5	82.0	83.5	84.9
18	54.6	56.0	57.4	58.8	60.2	61.6	63.0	64.4	65.8	67.2	68.6	70.1	71.5	73.0	74.4	75.9	77.3	78.8	80.3	81.8	83.3	84.8	86.3	87.8
19	56.8	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.2	69.7	71.1	72.6	74.1	75.5	77.0	78.5	80.0	81.5	83.1	84.6	86.1	87.6	89.2	90.7
20	59.0	60.4	61.9	63.3	64.8	66.3	67.7	69.2	70.7	72.2	73.7	75.2	76.7	78.2	79.8	81.3	82.8	84.4	85.9	87.5	89.1	90.7	92.2	93.8
21	61.3	62.8	64.3	65.8	67.3	68.8	70.3	71.8	73.3	74.9	76.4	77.9	79.5	81.1	82.6	84.2	85.8	87.4	89.0	90.6	92.2	93.8	95.4	97.1
22	63.8	65.3	66.8	68.3	69.8	71.4	72.9	74.5	76.1	77.6	79.2	80.8	82.4	84.0	85.6	87.2	88.9	90.5	92.1	93.8	95.5	97.1	98.8	100.5
23	66.3	67.8	69.4	71.0	72.5	74.1	75.7	77.3	78.9	80.5	82.2	83.8	85.4	87.1	88.7	90.4	92.1	93.8	95.5	97.2	98.9	100.6	102.4	104.1
24	68.9	70.5	72.1	73.7	75.3	77.0	78.6	80.3	81.9	83.6	85.2	86.9	88.6	90.3	92.0	93.8	95.5	97.2	99.0	100.7	102.5	104.3	106.1	107.9
25	71.7	73.3	75.0	76.6	78.3	80.0	81.7	83.3	85.1	86.8	88.5	90.2	92.0	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3	108.2	110.0	111.9
26	74.6	76.3	78.0	79.7	81.4	83.1	84.8	86.6	88.4	90.1	91.9	93.7	95.5	97.3	99.2	101.0	102.9	104.7	106.6	108.5	110.4	112.3	114.2	116.2
27	77.6	79.4	81.1	82.9	84.6	86.4	88.2	90.0	91.9	93.7	95.5	97.4	99.3	101.2	103.1	105.0	106.9	108.8	110.8	112.7	114.7	116.7	118.7	120.7
28	80.8	82.6	84.4	86.3	88.1	89.9	91.8	93.7	95.6	97.5	99.4	101.3	103.3	105.2	107.2	109.2	111.2	113.2	115.2	117.3	119.3	121.4	123.5	125.6
29	84.2	86.1	87.9	89.8	91.7	93.7	95.6	97.5	99.5	101.5	103.5	105.5	107.5	109.5	111.6	113.7	115.7	117.8	120.0	122.1	124.2	126.4	128.6	130.8
30	87.8	89.7	91.7	93.6	95.6	97.6	99.6	101.6	103.7	105.7	107.8	109.9	112.0	114.2	116.3	118.5	120.6	122.8	125.1	127.3	129.5	131.8	134.1	136.4
31	91.6	93.6	95.6	97.7	99.7	101.8	103.9	106.0	108.2	110.3	112.5	114.7	116.9	119.1	121.4	123.6	125.9	128.2	130.5	132.9	135.3	137.7	140.1	142.5
32	95.7	97.8	99.9	102.0	104.2	106.3	108.5	110.7	113.0	115.2	117.5	119.8	122.1	124.5	126.8	129.2	131.6	134.0	136.5	139.0	141.5	144.0	146.6	149.1
33	100.0	102.2	104.4	106.6	108.9	111.2	113.5	115.8	118.2	120.5	122.9	125.4	127.8	130.3	132.8	135.3	137.8	140.4	143.0	145.6	148.3	150.9	153.7	156.4
34	104.7	107.0	109.3	111.7	114.0	116.4	118.9	121.3	123.8	126.3	128.8	131.4	134.0	136.6	139.2	141.9	144.6	147.4	150.1	152.9	155.7	158.6	161.5	164.4
35	109.7	112.2	114.6	117.1	119.6	122.2	124.7	127.3	129.9	132.6	135.3	138.0	140.8	143.6	146.4	149.2	152.1	155.0	158.0	161.0	164.0	167.1	170.2	173.3
36	115.2	117.8	120.4	123.0	125.7	128.4	131.1	133.9	136.7	139.5	142.4	145.3	148.3	151.3	154.3	157.3	160.5	163.6	166.8	170.0	173.3	176.6	179.9	183.3
37	121.3	124.0	126.8	129.6	132.4	135.3	138.2	141.2	144.2	147.3	150.3	153.5	156.7	159.9	163.1	166.5	169.8	173.2	176.7	180.2	183.7	187.3	191.0	194.7
38	127.9	130.8	133.8	136.8	139.9	143.0	146.2	149.4	152.6	155.9	159.2	162.6	166.1	169.6	173.2	176.8	180.4	184.2	188.0	191.8	195.7	199.7	203.7	207.7
39	135.3	138.5	141.7	145.0	148.3	151.7	155.1	158.6	162.1	165.7	169.4	173.1	176.9	180.7	184.7	188.7	192.7	196.8	201.0	205.3	209.6	214.0	218.5	223.0
40	143.7	147.1	150.6	154.2	157.8	161.5	165.3	169.1	173.0	177.0	181.1	185.2	189.4	193.7	198.1	202.5	207.1	211.7	216.4	221.1	226.0	231.0	236.0	241.1
41	153.2	157.0	160.9	164.8	168.9	173.0	177.2	181.5	185.8	190.3	194.8	199.5	204.2	209.1	214.0	219.1	224.2	229.4	234.8	240.2	245.8	251.5	257.2	263.1
42	164.3	168.6	172.9	177.3	181.9	186.5	191.3	196.1	201.1	206.2	211.4	216.7	222.2	227.7	233.4	239.2	245.2	251.3	257.5	263.8	270.3	276.9	283.6	290.5
43	177.5	182.3	187.3	192.4	197.6	202.9	208.4	214.0	219.8	225.8	231.8	238.1	244.5	251.0	257.7	264.6	271.7	278.9	286.3	293.8	301.5	309.4	317.4	325.7
44	193.6	199.3	205.1	211.0	217.2	223.5	230.0	236.7	243.6	250.8	258.1	265.6	273.3	281.2	289.4	297.8	306.3	315.1	324.1	333.3	342.8	352.4	362.3	372.4
45	214.1	220.9	227.9	235.2	242.7	250.4	258.4	266.7	275.3	284.1	293.3	302.6	312.3	322.3	332.5	343.0	353.8	364.9	376.2	387.9	399.8	412.0	424.5	437.4
46	241.5	250.0	258.9	268.2	277.8	287.8	298.1	308.8	319.9	331.4	343.3	355.5	368.1	381.1	394.5	408.3	422.5	437.1	452.0	467.4	483.3	499.6	516.3	533.5
47	280.9	292.4	304.4	316.9	330.0	343.6	357.8	372.5	387.7	403.4	419.8	436.6	454.1	472.1	490.7	509.9	529.8	550.4	571.7	593.8	616.7	640.5	665.3	691.0
48	344.1	360.9	378.4	396.8	416.0	436.0	456.9	478.6	501.2	524.7	549.3	574.8	601.5	629.4	658.6	689.3	721.5	755.6	791.5	829.7	870.4	913.9	960.6	1011.2
49	461.1	488.4	517.2	547.5	579.4	613.1	648.8	686.7	727.0	770.1	816.4	866.4	920.8	980.4	1046.2	1119.9	1203.3	1299.7	1413.6	1553.1	1732.9	1986.3	2419.6	>2419.6

09-63235-01

D. Colilert Test Dilutions

If the first time the sample is analyzed, all of the wells turn yellow and fluoresce, then the *E. coli* and total coliform readings are higher than the maximum undiluted detection limit. The next time the bacteriological sample is collected, dilute the sample with sterile water. Sterilize the appropriate amount of Type I reagent grade organic free water in an autoclave and allow it to cool before inoculation or purchase sterilized water.

If an autoclave is not available, sterilized water may be purchased from commercial sources or obtained from TDH Central or Branch Laboratories. Water is only sterile until the bottle is opened. Do not store and reuse sterile water after the bottle has been opened.

Use a sterile disposable pipette or other sterile measuring container to measure the volume of sample and appropriate amount of sterile water to produce the proper dilution (Table 14). Then add reagent media and incubate as above (steps 1-5). Compare the number of yellow and/or fluorescing wells to the MPN table and multiply by the dilution factor to determine the total count.

Table 14: *E. coli* Detection Limit of Colilert Test

Dilution	**Factor**	**Count Range**
None	1X	1 to 2,419
1:10	10X	1 to 24,190
1:100	100X	1 to 241,900

E. Colilert Test Quality Control

Perform quality control check on each new lot of media reagent. The manufacture sells three Quanti-Cult™ or American Type Culture Collection (ATCC) pathogen standards (Table 15) that are used for quality control check of the reagent media and testing methods. To perform the quality control check, inoculate sterile water with the appropriate Quanti-Cult or ATCC pathogen standards and add the reagent media. Incubate and analyze the sample the using the Colilert method. Compare test results to the expected results supplied by the manufacture.

The analyses are being done correctly if the test results are similar to the expected results. If the results are significantly different, review the testing process and determine the probable origin of the problem. Correct any noted problems and repeat the QC test. For 10 percent of the samples analyzed run a quality control sample to ensure the samples are being run and interpreted correctly.

Table 15: Quality Control Organisms for Colilert Analyses

Quanti-Cult Organism	**ATCC#**	**Observation**	**Result**
E. coli	25922 or 11775	Yellow, fluorescence	+ Total coliform + *E. coli*
Kiebsiella pneumoniae	31488	Yellow, No fluorescence	+ Total coliform - *E. coli*
Pseudomonas aeruginosa	10145 or 27853	Clear, No Florescence	- Total Coliform -*E. coli*

Once a month check the Quanti-Tray® sealer by adding dye to a sample and sealing it. Commercially available dye, bromcresol purple, or 2-3 drops per 100 ml of food coloring may be added to a blank sample and poured into the Quanti-Tray®. Seal the Quanti-Tray® as usual. If dye is observed outside the wells, the seal is leaking and a new sealer should be used.

I.J. Data and Records Management

Data

Minimally all analysis results should be sent to the EAC that collected the samples and WPC Planning and Standards section. Hard copies of analysis results are maintained in the Central Office for at least 5 years. Chemical and bacteriological monitoring data and station location information can be found on the Access Water Quality Database. Contact WPC, PAS if assistance is needed in using this database. The master database is stored on the H drive at the central office. The database will be sent to the EACs near the beginning of each quarter.

Records

The Quality Team member (Section II.A) or their designee in each EAC checks that all chemical, bacteriological, and biological stations have been entered with complete information. Chemical and biological stations collected within 200 meters (yards) of each other are considered the same station and therefore will have the same station ID. If errors are found or stations are missing from the Access Water Quality Database please notify PAS in writing of the errors so they can be corrected. If stations are missing from the database, include the station name and location, Station ID, county, river mile, latitude/longitude, HUC code, ecoregion, and quad map. If errors are found in the database entries, please include the lab number, Station ID, sample date, and parameter in question. Also, if any analyses results appear incongruent contact the analyzing laboratory and copy PAS for verification of the readings, include laboratory number, station ID, and parameter result in question.

Note, if new stations are set up that will have chemical or bacteriological monitoring, send the station information (Protocol B) to the PAS before chemical and bacteriological results are received. It usually takes about a month from the time samples are collected for the results to be received.

II. QUALITY CONTROL AND QUALITY ASSURANCE

The U.S. EPA requires that a centrally planned, directed, and coordinated quality assurance and quality control program be applied to efforts supported by EPA through grants, contracts or other formalized agreements. This time allocation is an essential component of chemical and bacteriological sampling and analyses and is included in the annual work plan. This is not an optional or "as time allows" activity. The validity of all samples hinges on proving that neither the collection method nor the transport contaminated the samples.

Quality Assurance/Quality Control (field blanks, trip blanks, and duplicate) samples must be collected for at least 10 percent of the surface water sampling events. The goal is to demonstrate the accuracy and precision of the chemical and bacteriological collection process, the reproducibility of the methodology, and to ensure unbiased treatment of all samples. Choose QC sites that will be representative of all samples analyses in the 10-site QC set.

II.A. General QC Practices

1. **Quality Team Leader (QC coordinator)** - A centralized chemical and bacteriological QC coordinator is designated with the responsibility of ensuring that all QC protocols are met. This person will be an experienced water quality professional who participates in QC training and planning. Major responsibilities include monitoring QC activities to determine conformance, distributing quality related information, training personnel on QC requirements and procedures, reviewing QA/QC plans for completeness, noting inconsistencies, and signing off on the QA plan and reports.

2. **Quality Team Member (In-house QC officer)** - One WPC staff member in each EAC will be designated as the Quality Team Member (in-house QC officer) by the WPC Manager. The in-house QC officer should be an experienced water quality professional who participates in QC training and planning. This person will be responsible for performing and/or ensuring that quality control is maintained and for coordinating activities with the central Quality Team Leader (QC coordinator).

3. **Training** – There is no substitute for field experience. All samplers should have at least six months of field experience before selecting sampling sites. For on the job training, new employees should accompany experienced staff for as many different studies and sampling situations as possible. During this training period, the new employee needs to perform all tasks involved in sample collection under the supervision of experienced staff.

II.B. Quality Control Samples

It is mandatory that Trip Blanks, Field Blanks, and Duplicate samples be collected at a minimum of 10 percent of sampling events. The QC set must be representative of all types of samples collected in a series of ten sites. Collect Equipment Blanks at 10 percent of sample collections when an intermediate sampling device (bucket, bailer, peristaltic pump or Kemmerer) is used. A Temperature Blank to measure cooler temperature must accompany every cooler delivered to the laboratory if it arrives at the lab more than two hours after collection. If any QC sample is to be analyzed for trace metals or low level mercury, the modified clean technique (Protocol C) must be employed.

All trip, field, and equipment blank water must be Type I organic-free reagent grade water. TDH laboratories have Type I water filtration systems. This is not the DI tap. Request assistance if needed in locating or using the Type I water filtration system. Wash hands with phosphate-free soap before filling blank water containers and always wear powder-free gloves while filling the blank containers. Allow the Type I water filtration system to flush at least three minutes before obtaining blank water.

Store blank water in unused pre-cleaned, single use plastic bottles. Always keep an ample supply of fresh blank water on hand. TDH Laboratory recommends that blank water not be stored more than 28 days. Do not refill old bottles. Obtain a new bottle when replenishing blank water. Never top off stored water even within the 28-day period. Obtain Type I organic-free reagent grade blank water as close to the sampling event as possible. It is recommended that fresh blank water be obtained weekly.

1. **Trip Blanks** – The Trip Blank is used to determine if samples were contaminated during storage or transportation to the laboratory. In the EAC lab, immediately before departing for a sampling trip, fill the appropriate QC sample containers with Type I organic-free reagent grade water. Wear powder-free gloves when filling Nutrient Trip Blanks.

   Label the tag and Sample Request Form with the associated station ID, county code, date, military time, sampler, preservative, and sample type. Write "Trip Blank" on the description line of the Sample Request Form and in the remarks box on the sample tag. Attach a completed sample tag to each sample container and place the trip blank samples in a zip-type colorless plastic bag (optional). Store the Trip Blank QC sample on ice in a clean cooler. The sample is to remain closed the remainder of the trip.

2. **Field Blanks** – The Field Blank is used to determine if contamination originated from sources not associated with the surface water conditions. Near the sampling location, before collecting surface water samples, pour Type I organic-free reagent grade water from the storage container to the sample container(s). Wear powder-free gloves when filling Nutrient Field Blanks.

Label the tags and Sample Request Form as "Field Blank" and complete the associated station ID, county code, date, military time, sampler, preservative, and sample type. Attach a completed tag identified as "Field Blank" in the remarks box. Place the sample container in a zip-type colorless plastic bag (optional) and store the sample on ice in a clean cooler.

3. **Duplicate Sample** – The purpose of the duplicate sample is to determine variability of contaminates in surface water samples. Immediately after collecting a sample, fill a second sample container using the same technique. Label the tag and Sample Request Form as "Duplicate" and complete the station ID, county code, date, military time, sampler, preservative, and sample type. Attach the tag to the sample and place it in a zip-type colorless plastic bag (optional) and store on ice in a clean cooler until delivery to the lab.

4. **Temperature Blank** – A temperature blank is small bottle filled with water that is placed inside each cooler at the time the samples are stored in the cooler. When the samples are delivered to the laboratory, the temperature of the sample cooler is measured in the temperature blank to ensure it is $4^{o}C$ or less. Samples maintained at higher temperatures are flagged. (Note: If samples are delivered to the laboratory within 2 hours of collection, then temperatures greater than $4^{o}C$ are acceptable.)

5. **Equipment Field Blank** – After reusable equipment such as buckets, bailers, discrete depth samplers, or automatic sampler is cleaned, it is necessary to demonstrate that it is contaminant free. Collect equipment blanks at 10 percent of the sites where intermediate sampling devices are used. In the field before collecting the first sample, collect equipment blank by pouring organic-free reagent grade water over and through the equipment and collecting the sample into the appropriate sample container. Label the tag and Sample Request Form as "Equipment Field Blank" and complete with the associated station ID, county code, date, military time, sampler, preservative, and sample type. Attach the tag to the sample, place the sample in a colorless zip-type plastic bag (optional), and store on ice in a clean cooler until delivery to the laboratory.

6. **Instantaneous Field Water Parameter QC** – Calibrate all probes each day before use. (If overnight travel is involved, the probes may be calibrated at the beginning of the trip.) Take duplicate water parameter readings at each site. If time is a constraint, duplicate readings may be reduced to the first and last site each day. To take a duplicate reading, lift the probe completely out of the water, then place it upstream of the original reading and allow the meter to equilibrate before recording results. If the readings are off by more than 0.2 units (or 10% for conductivity), repeat the procedure until reproducible results are obtained.

   Upon return to the EAC Lab, perform a QC drift check on each meter at the end of the day (or at the end of the trip on multiple night trips). If the meter calibration is off by more than 0.2 for pH, DO or temperature or by more than 10% for conductivity, all readings between the initial calibration and the drift check must be marked as questionable. On the stream survey sheet and Chemical Request Form, precede questionable readings with an N (questionable data).

If Chemical Request Forms have already been submitted to the laboratory, notify the central office in writing (e-mail or fax) of questionable readings. See Protocol J for additional information on use of instantaneous water parameter meters and reporting of water parameters.

7. **Continuous Water Parameter QC** – At 10 percent of the diurnal monitoring stations anchor a second continuous monitoring probe beside the first. After the data from both probes has been downloaded, review the reading to ensure that they are within 10 percent of each other. If there is more than 10 percent difference between the two probe readings, notify the supervisor and note on all associated paper work (N) that there was a calibration error. See Protocol K for additional information.

8. **Flow Measurement QC –** Take a second flow measurement at 10 percent of the sites. The readings must be taken on the same day and in the same transect. If the original and the QC flow measurements differ by more than 10 percent, make a notation of N (uncertainty of results) on the associated paperwork. See Protocol L for additional information.

II.C. Chain of Custody

TDEC's Office of General Counsel requires that the chain of custody (Figure 6) be completed for any sample that has the potential of being used in court, reviewed by the Water Quality Control Board, or involved in state hearings. Therefore, all samples are potentially legal and the integrity of the sample must be beyond question. The chain of custody is located in the right column of the TDH Environmental Laboratory's Chemical Analyses Forms (Appendix A). If using another TDEC contract lab, a separate chain of custody must be completed (Appendix A). The entire form must be filled out completely and maintained with the chain of custody paperwork. See Protocol I for additional details on completing the Chemical Request Forms.

The chain of custody follows the sample through collection, transfer, storage, analyses, quality assurance, and disposal. Sign (do not print or initial) first and last name in the collected by space followed by date and military time of collection. When the sample is transferred to the next sample custodian, write the name of the person or place receiving the sample and the date and military time of custody transfer. Each custodian of the sample must sign their full name on the received by space with the date and military time the sample was received and complete the delivered to section when it is transferred from their custody. Upon arrival at the laboratory, the person who receives the sample, signs the received in the lab by line followed by the date and military time of receipt. When the sample is logged into the LIMS system, the person who logs in the sample, signs and dates the logged in by line.

Contact the laboratory if samples cannot be delivered during normal hours of operation. If holding times are not an issue, it may be best to secure the samples in a locked area in the EAC and deliver them to the laboratory the next day. It also may be possible to arrange for someone at the laboratory to receive the sample after hours. In either of these scenarios, the laboratory personnel will sign the chain-of-custody. The final and least desirable option for after hour delivery is to have the security guard sign the chain-of-custody and secure the samples. The branch labs do not have security guards on duty so arrangements must be made ahead of time.

The second half of the chain of custody titled Additional Information is equally important. Complete the bottom half of the right column of the Sample Request Form. Fill out approximate volume of sample, nearest town or city, others present at collection, number of other samples collected at same time at this point, field collection procedure, handling and/or preservation of this sample, and mode of transportation to lab. Sign and date the sample sealed by line and write any remarks or special notations about the sample on the last line.

II.D. Laboratory Detection Limits

In most cases, samples will be sent to the TDH Environmental Laboratory for analyses. This laboratory meets required detection limits for WPC. In special instances (short holding times, grants or collections performed by non-WPC individuals) another TDEC contract laboratory may be used. It is required that the sampler verify that specified detection limits (Appendix B) will be met and that results will be reported in the designated units. The sampler must also insure that both hard copies and electronic database results will be sent to PAS.

III. REFERENCES

American Public Health Association, American Waterworks Association, Water Environment Federation. 1995. *19th Edition, Standard Methods for Examination of Water and Wastewater.* American Public Health Association. Washington, D.C.

Buchanan, Thomas J. and William P. Somers. 1976. Chapter A8, *Discharge Measurements at Gaging Stations*, Book 3, Applications of Hydraulics, in Techniques of Water-Resources Investigations of the United States Geological Survey. United States Geological Survey. Washington, D.C.

Florida Department of Environmental Protection. 2002. *Department of Environmental Protection Standard Operating Procedure for Field Activities*. Bureau of Laboratories, Environmental Assessment Section. Tallahassee, Florida. DEP-SOP-001/01.

Hydrolab Corporation. 2002. *Barometric Pressure, Hydolab Technical #203*. Loveland, Colorado.

Kentucky Department for Environmental Protection. 2002. *Kentucky Ambient/Watershed Water Quality Monitoring Standard Operating Procedure Manual*. Water Quality Branch, Division of Water. Frankfort, Kentucky. 61 pp.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters.* EPA/600/4-90/030. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio.

Lurry, D.L. and C.M. Kolbe (Compilers). 2000. *Interagency Field Manual for the Collection of Water-Quality Data.* Open-File Report 00-213. U.S.G.S. Austin, Texas.

McGrath, Laura. Environmental Engineer. November 3, 2003. Personnel communication. USEPA, Region 4, Science and Ecosystem Support Division. Athens, Georgia.

Occupational Safety and Health Administration. 1993. *Revision 3*, *Manual on Uniform Traffic Control Devices:* Part VI Standards and Guides for Traffic Controls for Street and Highway Construction, Maintenance, Utility, and Incident Management Operations. Washington, D.C.

Tennessee Department of Environment and Conservation. 1996. *Gauging Flow in Wadeable Streams.* Nashville Environmental Assistance Center, Division of Water Pollution Control. Nashville, Tennessee.

_____. 1996. *Standard Operating Procedure for Modified Clean Technique Sampling Protocol.* Division of Water Pollution Control. Nashville, Tennessee.

_____. 1998. *Division of Water Pollution Control Environmental Assistance Center Standard Operating Procedures Manual*. Division of Water Pollution Control. Nashville, Tennessee.

_____. 2001. *Monitoring to Support TMDL Development*. Division of Water Pollution Control, Watershed Management Section. Nashville, Tennessee.

_____. 2002. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys.* Division of Water Pollution Control. Nashville, Tennessee.

_____. 2003. *Tennessee Division of Water Pollution Control Monitoring and Planning Workplan*. Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Environment and Conservation Water Quality Control Board. 2003. *Rules of the Tennessee Department of Environment and Conservation Division of Water Pollution Control,* Chapter 1200-4-3, General Water Quality Criteria. Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Health. 2001. *Environmental Sample Collection and Handling Information from the Tennessee Directory of Laboratory Services.* Tennessee Environmental Laboratories. Nashville, Tennessee.

_____. 2001. *Laboratory Seminar for Field Environmentalists.* Tennessee Environmental Laboratories. Nashville, Tennessee.

_____. 2003. *Standard Operating Procedure – Safety*. Tennessee Environmental Laboratories, Aquatic Biology Section. Nashville, Tennessee.

Tennessee Secretary of State. 1994. *The Tennessee Water Quality Control Act of 1977 including the 1994 amendments.* Nashville, Tennessee. 29 pp.

Turnbull, Wayne. October 7, 2003. Personnel communication. USEPA, Region 4, Science and Ecosystem Support Division. Athens, Georgia.

United States Congress. 2000. *Federal Water Pollution Control Act As Amended Through P.L. 109-308.* 33 U.S.C. 1251 et. seq. Washington D.C. 223 pp.

United States Environmental Protection Agency. 1990. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters.* Aquatic Biology Branch and Development and Evaluation Branch, Quality Assurance Research Division, Environmental Monitoring Systems Laboratory. Cincinnati, Ohio.

_____. 1996. *Method 1669 Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels.* Office of Water Engineering and Analysis Division (4303). Washington, D.C.

_____. 1996. *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit from a Dissolved Criterion.* Office of Water (4305). Washington, D.C.

_____. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, Georgia.

_____. 2001. *Guidance for Preparing Standard Operating Procedures (SOP)*. Quality Staff. Washington, D.C.

_____. 2002. *Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* Region 4. Atlanta, Georgia.

United States Geological Survey. 1999. *Nation Field Manual for the Collection of Water-Quality Data,* Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigation. Water Resources-Office of Water Quality. Denver, Colorado.

IV. APPENDICES

APPENDIX A

FORMS AND DATA SHEETS

County Abbreviations and Code Numbers
TDH Environmental Laboratories Sample Container Order Sheet
TDH Inorganic Analysis Sample Request Form
TDH Organic Analysis; Base/Neutral/Acid Extractable Sample Request Form
TDH Organic Analysis; Volatiles and Petroleum Hydrocarbons
Sample Request Form
Chain of Custody
Field Flow Measurement Sheet
Flow Measurement Sheet (Excel Formulas)

COUNTY – Abbreviations and Code Numbers

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
ANDERSON	**AN**	01	001	LAUDERDALE	**LE**	49	097
BEDFORD	**BE**	02	003	LAWRENCE	**LW**	50	099
BENTON	**BN**	03	005	LEWIS	**LS**	51	101
BLEDSOE	**BL**	04	007	LINCOLN	**LI**	52	103
BLOUNT	**BT**	05	009	LOUDON	**LO**	53	105
BRADLEY	**BR**	06	011	MCMINN	**MM**	54	107
CAMPBELL	**CA**	07	013	MCNAIRY	**MC**	55	109
CANNON	**CN**	08	015	MACON	**MA**	56	111
CARROLL	**CR**	09	017	MADISON	**MN**	57	113
CARTER	**CT**	10	019	MARION	**MI**	58	115
CHEATHAM	**CH**	11	021	MARSHALL	**ML**	59	117
CHESTER	**CS**	12	023	MAURY	**MY**	60	119
CLAIBORNE	**CL**	13	025	MEIGS	**ME**	61	121
CLAY	**CY**	14	027	MONROE	**MO**	62	123
COCKE	**CO**	15	029	MONTGOMERY	**MT**	63	125
COFFEE	**CE**	16	031	MOORE	**MR**	64	127
CROCKETT	**CK**	17	033	MORGAN	**MG**	65	129
CUMBERLAND	**CU**	18	035	OBION	**OB**	66	131
DAVIDSON	**DA**	19	037	OVERTON	**OV**	67	133
DECATUR	**DE**	20	039	PERRY	**PE**	68	135
DE KALB	**DB**	21	041	PICKETT	**PI**	69	137
DICKSON	**DI**	22	043	POLK	**PO**	70	139
DYER	**DY**	23	045	PUTNAM	**PU**	71	141
FAYETTE	**FA**	24	047	RHEA	**RH**	72	143
FENTRESS	**FE**	25	049	ROANE	**RO**	73	145
FRANKLIN	**FR**	26	051	ROBERTSON	**RN**	74	147
GIBSON	**GI**	27	053	RUTHERFORD	**RU**	75	149
GILES	**GS**	28	055	SCOTT	**SC**	76	151
GRAINGER	**GR**	29	057	SEQUATCHIE	**SE**	77	153
GREENE	**GE**	30	059	SEVIER	**SV**	78	155
GRUNDY	**GY**	31	061	SHELBY	**SH**	79	157
HAMBLEN	**HA**	32	063	SMITH	**SM**	80	159
HAMILTON	**HM**	33	065	STEWART	**ST**	81	161
HANCOCK	**HK**	34	067	SULLIVAN	**SU**	82	163
HARDEMAN	**HR**	35	069	SUMNER	**SR**	83	165
HARDIN	**HD**	36	071	TIPTON	**TI**	84	167
HAWKINS	**HS**	37	073	TROUSDALE	**TR**	85	169

COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS	COUNTY NAME	WPC CO ABBR	TN CO NO	NATIONAL TN FIPS
HAYWOOD	**HY**	38	075	UNICOI	**UC**	86	171
HENDERSON	**HE**	39	077	UNION	**UN**	87	173
HENRY	**HN**	40	079	VAN BUREN	**VA**	88	175
HICKMAN	**HI**	41	081	WARREN	**WA**	89	177
HOUSTON	**HO**	42	083	WASHINGTON	**WN**	90	179
HUMPHREYS	**HU**	43	085	WAYNE	**WE**	91	181
JACKSON	**JA**	44	087	WEAKLEY	**WY**	92	183
JEFFERSON	**JE**	45	089	WHITE	**WH**	93	185
JOHNSON	**JO**	46	091	WILLIAMSON	**WI**	94	187
KNOX	**KN**	47	093	WILSON	**WS**	95	189
LAKE	**LA**	48	095				

TDH Environmental Laboratories
Sample Container Order Sheet

Requesting Agency_____ **Name**_____
Date/Time Requested by_____
Date Received_____ **Received by**_____

Lab Inv#	Container	Analytes	Requested	Issued
Liquids				
100-4320	40 mL Amber Vial,	GRO, VOA	_____	_____
100-0700	250 mL Amber Glass	TOX	_____	_____
100-0420	500 mL Glass Bottle	Sulfide	_____	_____
100-0440	1000 mL Amber Glass Bottle	Ext. Organics, DRO, Phenols, Petroleum Products	_____	_____
100-0450	1 Gallon Amber Glass Bottle	Extractable Organics	_____	_____
200-0200	125 mL Plastic Bottle	Boron, Fluoride	_____	_____
350-4715	250 mL Plastic Bottle	Bacteriological	_____	_____
200-0280	500 mL Plastic Bottle	Nutrients, TOC, Mercury	_____ _____	_____ _____
200-0300	1000 mL Plastic Bottle	Metals, Cyanide, Routines	_____ _____	_____ _____
200-0340	1 Gallon Plastic Bottle	BOD, Routines w/ Settleable Solids, Radiological	_____	_____
Solids				
100-0740	4 oz. Amber Glass Jar	VOA, BTEX, GRO	_____	_____
100-0760	16 oz. Amber Glass Jar	Extractable Organics, DRO, Metals, TCLP, Ignitability	_____ _____	_____ _____
200-0725	Encore Devices	VOA Solids	_____	_____

Miscellaneous

Forms: Inorganic:_____ Extractable Organics:_____ Volatile Organics:_____
Safe Drinking Water:_____ Radiochemisty:_____ Sample Container Tags:_____

Notes: _____

State of Tennessee - Environmental Laboratories

Inorganic Analysis

PLEASE PRINT LEGIBLY

PROJECT/SITE NO.	**PROJECT NAME**
STATION NUMBER	**COUNTY**
DESCRIPTION	
STREAM MILE	**DEPTH** **MATRIX**
COLLECTED: DATE	**TIME**
SAMPLER'S NAME (printed)	
SAMPLING AGENCY	**BILLING CODE**
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	Env. Microbiology
	coliform, fecal*
	coliform, total*
	strep, fecal*
	E. Coli*
	Enterococcus*
*	**Ambient Parameters**
	COD*
	coliform, fecal
	conductivity*
	hardness, total as $CaCO_3$*
	nitrogen, ammonia
	nitrogen, NO_3 & NO_2
	nitrogen, total Kjeldahl
	phosphate, total
	pH
	residue, dissolved*
	residue, suspended*
	arsenic, As
	cadmium, Cd
	chromium, Cr
	copper, Cu
	lead, Pb
	mercury, Hg
	nickel, Ni
	zinc, Zn

*	General Inorganics
	acidity as $CaCO_3$*
	alkalinity as $CaCO_3$*
	alkalinity, phen. as $CaCO_3$*
	BOD, 5-day*
	CBOD, 5-day*
	boron
	chloride*
	chlorine, residual*
	chromium, hexavalent
	COD*
	color, apparent*
	color, true*
	conductivity*
	cyanide
	flash point*
	fluoride*
	hardness, Ca as $CaCO_3$*
	hardness, total as $CaCO_3$*
	hydrocarbons, total
	MBAS*
*	**Other**
	nitrogen, ammonia
	nitrogen, nitrate*
	nitrogen, nitrite*
	nitrogen, NO_3 & NO_2
	nitrogen, total Kjeldahl
	nitrogen, total organic

	Gen. Inorganics (con't)
	oil and grease
	orthophosphate, total*
	oxygen, dissolved*
	pH
	phenols, total
	phosphate, total
	residue, dissovled*
	residue, settleable*
	residue, suspended*
	residue, total*
	silica*
	sulfate*
	sulfide, total*
	TOC*
	turbidity*
	percent solids
*	**Asbestos**
	bulk asbestos
	other microscopic

*	Metals
	aluminum, Al
	antimony, Sb
	arsenic, As
	barium, Ba
	beryllium, Be
	cadmium, Cd
	calcium, Ca
	chromium, Cr
	cobalt, Co
	copper, Cu
	iron, Fe
	lead, Pb
	magnesium, Mg
	manganese, Mn
	mercury, Hg
	nickel, Ni
	potassium, K
	selenium, Se
	silver, Ag
	sodium, Na
	thallium, Tl
	vanadium, V
	zinc, Zn
*	**TCLP**
	arsenic, As
	barium, Ba
	cadmium, Cd
	chromium, Cr
	lead, Pb
	mercury, Hg
	nickel, Ni
	selenium, Se
	silver, Ag

** denotes analyses performed only on water*

FIELD DETERMINATIONS	Temperature
pH	Chlorine, residual
Conductivity	Other
Dissolved Oxygen	

Laboratory Number

Branch Lab Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   Date Time
   Delivered to
   Date Time
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by
   Date Time
   Logged in by
   Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

PH-3011 (rev 10/98)

RDA 1527

State of Tennessee - Environmental Laboratories

Organic Analysis

Base/Neutral/AcidExtractables

PLEASE PRINT LEGIBLY

PROJECT/SITE NO.	**PROJECT NAME**
STATION NUMBER	**COUNTY**
DESCRIPTION	
STREAM MILE	**DEPTH** **MATRIX**
COLLECTED: DATE	**TIME**
SAMPLER'S NAME (printed)	
SAMPLING AGENCY	**BILLING CODE**
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	**NPDES** Extractables
	butylbenzylphthalate
	bis(2-ethylhexyl)phthalate
	di-n-butylphthalate
	di-n-octylphthalate
	diethylphthalate
	dimethylphthalate
	n-nitrosodimethylamine
	n-nitrosodiphenylamine
	n-nitrosodi-n-propylamine
	isophorone
	nitrobenzene
	2,4-dinitrotoluene
	acenaphthene
	acenaphthylene
	anthracene
	benzo(a)anthracene
	benzo(a)pyrene
	benzo(b)fluoranthene
	benzo(b)fluoranthene
	benzo(g,h,i)perylene
	benzo(k)fluoranthene
	chrysene
	dibenzo(a,h)anthracene
	fluoranthene
	fluorene
	indeno(1,2,3-c,d)pyrene
	naphthalene
	phenanthrene
	pyrene
	bis(2-chloroethyl)ether
	bis(2-chloroethoxy)methane
	bis(2-chloroisopropyl)ether
	4-bromophenylphenylether
	4-chlorophenylphenylether
	hexachlorocyclopentadiene
	hexachlorobutadiene
	hexachlorobenzene
	hexachloroethane
	1,2,4-trichlorobenzene
	2-chloronaphthalene
	4-chloro-3-methyl phenol

*	**NPDES** Extractables(cont'd)
	2-chlorophenol
	2,4-dichlorophenol
	2,4-dimethylphenol
	2,4-dinitrophenol
	4,6-dinitro-o-cresol
	2-nitrophenol
	4-nitrophenol
	pentachlorophenol
	phenol
	2,4,6-trichlorophenol

*	**TAL** Semivolatiles
	acenaphthene
	anthracene
	benzo(a)anthracene
	benzo(a)pyrene
	benzo(b)fluoranthene
	benzo(g,h,i) perylene
	benzo(k)fluoranthene
	benzoic acid
	benzyl alcohol
	bis(2-chloroethoxy)methane
	bis(2-chloroethyl) ether
	bis(2-chloroisopropyl)ether
	bis(2-ethylhexyl)phthalate
	4-bromophenylphenylether
	butylbenzylphthalate
	4-chloroaniline
	4-chloro-3-methyl phenol
	2-chloronaphthalene
	4-chlorophenylphenylether
	chrysene
	di-n-butylphthalate
	di-n-octylphthalate
	dibenzofuran
	3,3'-dichlorobenzidine
	2,4-dichlorophenol
	diethylphthalate
	2,4-dimethylphenol

*	**TAL** Semivolatiles
	dimethylphthalate
	4,6-dinitro-2-methylphenol
	2,4-dinitrophenol
	2,6-dinitrotoluene
	fluoranthene
	fluorene
	hexachlorobenzene
	hexachlorobutadiene
	hexachlorocyclopentadiene
	hexachloroethane
	indeno(1,2,3-cd)pyrene
	isophorone
	2-methylnaphthalene
	2-methylphenol
	4-methylphenol
	n-nitrosodiphenylamine
	n-nitroso-n-dipropylamine
	naphthalene
	2-nitroaniline
	3-nitroaniline
	4-nitroaniline
	nitrobenzene
	2-nitrophenol
	4-nitrophenol
	pentachlorophenol
	phenol
	pyrene
	1,2,4-trichlorobenzene
	2,4,5-trichlorophenol
	2,4,6-trichlorophenol
*	**Nitrobodies**
	RDX
	2,4,6-TNT
	2,4-dinitrotoluene
	2,6-dinitrotoluene
	nitrobenzene
	1,3,5-TNB

*	**TCLP** Semivolatiles
	chlordane
	o-cresol
	m-cresol
	p-cresol
	cresol
	2,4-D
	2,4-dinitrotoluene
	endrin
	heptachlor
	heptachlorepoxide
	hexachlorobenzene
	hexachlorobutadiene
	hexachloroethane
	lindane
	methoxychlor
	nitrobenzene
	pentachlorophenol
	pyridine
	toxaphene
	2,4,5-trichlorophenol
	2,4,6-trichlorophenol
	2,4,5-TP (Silvex)
*	**Pesticides/PCBs**
	aldrin
	alpha-BHC
	beta-BHC
	delta-BHC
	gamma-BHC (lindane)
	technical chlordane
	alpha-chlordane
	gamma-chlordane
	4,4'-DDD
	4,4'-DDE
	4,4'-DDT
	dieldrin
	endosulfan I
	endosulfan II
	endosulfan sulfate
	endrin
	endrin aldehyde
	endrin ketone
	heptachlor
	heptachlor epoxide
	toxaphene
	methoxychlor
	PCB 1016/1242
	PCB 1221
	PCB 1232
	PCB 1248
	PCB 1254
	PCB 1260
	PCB 1262

Laboratory Number

Branch Lab Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   Date Time
   Delivered to
   Date Time
2. Received by
   Date Time
   Delivered to
   Date Time
3. Received by
   Date Time
   Delivered to
   Date Time
4. Received in Lab by
   Date Time
   Delivered to
   Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

PH-3014 (rev 1/96)

RDA 1527

State of Tennessee - Environmental Laboratories

PLEASE PRINT LEGIBLY

Organic Analysis

Volatiles and Petroleum Hydrocarbons

PROJECT/SITE NO.	PROJECT NAME
STATION NUMBER	COUNTY
DESCRIPTION	
STREAM MILE	DEPTH MATRIX
COLLECTED: DATE	TIME
SAMPLER'S NAME(printed)	
SAMPLING AGENCY	BILLING CODE
IF PRIORITY, DATE NEEDED	
SEND REPORT TO:	
CONTACT HAZARD	

*	NPDES Volatiles - 624	*	TCL Volatiles - 8260A	*	TCLP Volatiles
	Bromoform		Chloromethane		Benzene
	Bromodichloromethane		Bromomethane		Carbon tetrachloride
	Carbon Tetrachloride		Vinyl chloride		Chlorobenzene
	Chlorobenzene		Chloroethane		Chloroform
	Chloroethane		Methylene chloride		1,2-Dichloroethane
	2-Chloroethylvinyl ether		Acetone		1,1-Dichloroethane
	Chloroform		Carbon disulfide		Methyl ethyl ketone
	Chloromethane		1,1-Dichloroethene		Tetrachloroethene
	Dibromochloromethane		1,1-Dichloroethane		Trichloroethene
	1,2-Dichlorobenzene		Cis-1,2-dichloroethene		Vinyl chloride
	1,3-Dichlorobenzene		Trans-1,2-dichloroethene	*	BTEX - 8260A - UST
	1,4-Dichlorobenzene		1,2-Dichloroethane		Benzene
	Dichlorodifluoromethane		Chloroform		Toluene
	1,1-Dichloroethane		2-Butanone		Ethyl benzene
	1,2-Dichloroethane		1,1,1-Trichloroethane		o-Xylene
	1,1-Dichloroethene		Carbon tetrachloride		m-Xylene
	Cis-1,2-dichloroethene		Vinyl acetate		p-Xylene
	Trans-1,2-dichloroethene		Bromodichloromethane		Methyl t-butyl ether
	1,2-Dichloropropane		1,2-Dichloropropane		Diisopropyl ether
	Cis-1,3-dichloropropene		Cis-1,3-dichloropropene	*	TPH by GC
	Trans-1,2-dichloroethene		Trichloroethene		Gasoline Range Organics
	Methylene chloride		Dibromochloromethane		Diesel Range Organics
	1,1,2,2-Tetrachloroethane		1,1,2-Trichloroethane		Oil Range Organics
	Tetrachloroethene		Benzene	*	Other
	1,1,1-Trichloroethane		Trans-1,3-dichloropropene		
	1,1,2-Trichloroethane		Bromoform		
	Trichloroethene		4-Methyl-2-pentanone		
	Trichlorofluoromethane		2-Hexanone		
	Vinyl chloride		Tetrachloroethene		
	Benzene		Toluene		
	Ethylbenzene		1,1,2,2-Tetrachloroethane		
	Toluene		Chlorobenzene		
	o-Xylene		Ethyl benzene		
	m-Xylene		Styrene		
	p-Xylene		o-Xylene		
			m-Xylene		
			p-Xylene		

Laboratory Number

Chain of Custody and Supplemental Information

Only one chain of custody form is required per sample set or point (if all collected at the same time)

1. Collected by
   - Date Time
   - Delivered to
   - Date Time
2. Received by
   - Date Time
   - Delivered to
   - Date Time
3. Received by
   - Date Time
   - Delivered to
   - Date Time
4. Received in Lab by
   - Date Time
   - Logged in by
   - Date Time

Additional Information

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

PH-3013 (rev 11/97)

RDA 1527

Chain of Custody

PROJECT/SITE NO.	PROJECT NAME
STATION NUMBER	COUNTY
DESCRIPTION	
STREAM MILE	MATRIX
COLLECTED: DATE	TIME
SAMPLER'S NAME (printed)	
SAMPLING AGENCY	
Laboratory Number	Branch Lab Number

CHAIN OF CUSTODY

Only one chain of custody form is required per sample set or point (if all collected at the same time)	
1. Collected by	
Date	Time
Delivered to	
Date	Time
2. Received by	
Date	Time
Delivered to	
Date	Time
3. Received by	
Date	Time
Delivered to	
Date	Time
4. Received in Lab by	
Date	Time
Logged in by	
Date	Time

ADDITIONAL INFORMATION

1. Approximate volume of sample
2. Nearest town or city
3. Others present at collection
4. Number of other samples collected at same time at this point.
5. Field collection procedure, handling and/or preservation of this sample
6. Mode of transportation to lab
7. Sample sealed by
8. Date sample sealed
9. Remarks

From PH-3011 (rev 10/98), PH-3013 (rev 11/97), and PH-3014 (rev 1/96)

Field Flow Measurement Sheet

Station ID: _____ Date: _____
Stream Name: _____ Time: _____
Location: _____ Previous Rain: _____
Samplers: _____ Flow Meter ID: _____

Tape Reading (feet)	**Depth** (feet)	**Velocity** (ft/sec)	**Distance** (feet) (from LDB)	**Cell Width** (feet)	**Comments**
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					

Flow Measurement Sheet (Excel Formulas)

Station ID:	**Date:**	**Peak Velocity =**	**MAX(C10:C41)**
Stream Name:	**Time:**	**Avg. Velocity =**	**AVERAGE(C10:C41)**
Location:	**Previous Rain:**	**Max. Depth =**	**MAX(B10:B41)**
Sampler:	**Flow meter ID#:**	**Avg. Depth =**	**AVERAGE(B10:B41)**

Tape Reading (in order)	Depth (feet)	Velocity (ft/sec.)	Distance (ft) (from LDB)	Cell Width (feet)	Flow/Cell (cfs)
			0	=(D11-D10)/2	=B10*E10*C10
			=A11-A10	=(D12-D10)/2	=B11*E11*C11
			=A12-A10	=(D13-D11)/2	=B12*E12*C12
			=A13-A10	=(D14-D12)/2	=B13*E13*C13
			=A14-A10	=(D15-D13)/2	=B14*E14*C14
			=A15-A10	=(D16-D14)/2	=B15*E15*C15
			=A16-A10	=(D17-D15)/2	=B16*E16*C16
			=A17-A10	=(D18-D16)/2	=B17*E17*C17
			=A18-A10	=(D19-D17)/2	=B18*E18*C18
			=A19-A10	=(D20-D18)/2	=B19*E19*C19
			=A20-A10	=(D21-D19)/2	=B20*E20*C20
			=A21-A10	=(D22-D20)/2	=B21*E21*C21
			=A22-A10	=(D23-D21)/2	=B22*E22*C22
			=A23-A10	=(D24-D22)/2	=B23*E23*C23
			=A24-A10	=(D25-D23)/2	=B24*E24*C24
			=A25-A10	=(D26-D24)/2	=B25*E25*C25
			=A26-A10	=(D27-D25)/2	=B26*E26*C26
			=A27-A10	=(D28-D26)/2	=B27*E27*C27
			=A28-A10	=(D29-D27)/2	=B28*E28*C28
			=A29-A10	=(D30-D28)/2	=B29*E29*C29
			=A30-A10	=(D31-D29)/2	=B30*E30*C30
			=A31-A10	=(D32-D30)/2	=B31*E31*C31
			=A32-A10	=(D33-D31)/2	=B32*E32*C32
			=A33-A10	=(D34-D32)/2	=B33*E33*C33
			=A34-A10	=(D35-D33)/2	=B34*E34*C34
			=A35-A10	=(D36-D34)/2	=B35*E35*C35
			=A36-A10	=(D37-D35)/2	=B36*E36*C36
			=A37-A10	=(D38-D36)/2	=B37*E37*C37
			=A38-A10	=(D39-D37)/2	=B38*E38*C38
			=A39-A10	=(D40-D38)/2	=B39*E39*C39
			=A40-A10	=(D41-D39)/2	=B40*E40*C40
			=A41-A10	=(D41-D40)/2	=B41*E41*C41

Stream Width =	**=D41**	**Avg. Flow (cfs) =**	**=SUM(F10:F41)**

APPENDIX B

TESTS, CONTAINERS, AND HOLDING TIMES

TDH Bacteriological Analyses Available
TDH Routine Analyses Available
TDH Nutrient Analyses Available
TDH Metal Analyses Available
TDH Miscellaneous Inorganic Analyses Available
TDH Organic Analyses Available

TDH Bacteriological Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Coliform, fecal		6 hours	Two 250 mL plastic	Sodium Thiosulfate ($Na_2S_2O_3$). Bottles are labeled with preparation date and expiration date. Do not use expired bottles.
Coliform, total		48 hours		
E. coli		6 hours		
Strep, fecal		6 hours		

Store on ice at 4°C.

TDH Routine Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Acidity	1 mg/L	14 days	1 liter plastic*	None
Alkalinity	10 mg/L	14 days		
Alkalinity, phen.	2 mg/L	14 days		
BOD, 5-day	2 mg/L	48 hours		
CBOD, 5-day	2 mg/L	48 hours		
Chloride	1 mg/L	28 days		
Chlorine, residual	0.1 mg/L	Test immed.		
Chromium, hexavalent	10 µg/L	24 hours		
Conductivity		Field		
Fluoride	0.1 mg/L	28 days		
Hardness, calcium	1 mg/L	14 days		
Hardness, total	10mg/L	14 days		
Nitrogen, nitrite	0.01 mg/L	48 hours		
Orthophosphate, total	0.01 mg/L	48 hours		
Oxygen, dissolved		Field		
pH		Field		
Silica	0.2 mg/L	7 days		
Sulfate	2 mg/L	28 days		
Turbidity	0.1 NTU	48 hours		
MBAS	0.025 mg/L	48 hours	1 gallon plastic	
Color, apparent	3 Pt Co	48 hours		
Color, true	3 Pt Co	48 hours		
Residue, dissolved	10 mg/L	7 days		
Residue, suspended	10 mg/L	7 days		
Residue, settleable	0.1 mg/L	48 hours		
Residue, total	10 mg/L	7 days		

All plastics are one time use. Store on ice at 4°C.
No preservative is needed for Routine Samples.
*If multiple analyses are needed, collect 1 gallon of sample to assure adequate volume is available for analyses and QC. Contact TDH Lab if assistance is needed to determine how much sample to collect.

TDH Nutrient Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
COD	5 mg/L	28 days	500 mL plastic	1 mL sulfuric acid (H_2SO_4)
Nitrogen, ammonia	0.02 mg/L	28 days		
Nitrogen, nitrate	0.01 mg/L	28 days		
Nitrogen, NO_3 & NO_2	0.01 mg/L	28 days		
Nitrogen, total kjeldahl (TKN)	0.1 mg/L	28 days		
Nitrogen, total organic	0.1 mg/L	28 days		
Phosphorus, total	0.004 mg/L	28 days		
TOC	1 mg/L	28 days		

All plastics are one time use. Store on ice at 4°C.

TDH Metals Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Aluminum, Al	100 µg/L	6 months	1 liter plastic	5 mL 70% Nitric Acid (HNO_3)
Antimony, Sb	3 µg/L			
Arsenic, As	1 µg/L			
Barium, Ba	100 µg/L			
Beryllium, Be	1 µg/L			
Cadmium, Cd	1 µg/L			
Calcium, Ca	2 mg/L			
Chromium, Cr	1 µg/L			
Cobalt, Co	2 µg/L			
Copper, Cu	1 µg/L			
Iron, Fe	25 µg/L			
Lead, Pb	1 µg/L			
Magnesium, Mg	0.02 mg/L			
Manganese, Mn	5 µg/L			
Nickel, Ni	10 µg/L			
Potassium, K	0.3 mg/L			
Selenium, Se	2 µg/L			
Silver, Ag	1 µg/L			
Sodium, Na	0.1 mg/L			
Thallium, Tl	2 µg/L			
Vanadium, V	2 µg/L			
Zinc, Zn	1 µg/L			
Mercury, Hg	0.2 µg/L	28 days	500 mL plastic	2.5 mL 70% Nitric Acid (HNO_3)

All plastics are one time use. Store on ice at 4°C.
Metals and Mercury samples must be collected using the modified clean technique.

TDH Miscellaneous Inorganic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Cyanide	0.02 mg/L	14 days	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide ($NaOH_9$) at collection. 0.6 g ascorbic acid ($C_6H_8O_6$) if KI paper indicates chlorine.
Oil & Grease	5 mg/L	28 days	1 liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4)
Phenols, total	10 µg/L	28 days	1 liter glass, amber	2 mL sulfuric acid (H_2SO_4)
Sulfide	1 mg/L	7 days	500 mL glass	2 mL zinc acetate (ZnAc) in laboratory. 5 mL 50% sodium hydroxide (NaOH) in field.
Boron	200 µg/L	6 months	125 mL plastic	0.75 mL hydrochloric acid (HCl)
Flash Point		None specified	16-ounce glass Teflon® lined lid	None
TCLP		28 days	16-ounce glass jar*	None
TOC	1 mg/L		125 mL plastic	0.25 mL sulfuric acid (H_2SO_4)

All plastics are one time use. Store on ice at 4°C.
*Due to analysis requirements, could require much more sample. (See Protocol C)

TDH Organic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Base/Neutral/Acid Extractables				
NPDES Extrac.		7 days to extract; 40 days to analyze	One 1-gallon amber bottle, acetone-rinsed, and Teflon®-lined cap.	None
Pesticides/PCBs				
TAL Extrac.				
Nitrobodies				
Semivolatiles				
Volatiles and Petroleum Hydrocarbons				
NPDES Volatiles		14 days	Four 40-mL amber vials, Teflon®-lined septa caps, no headspace.	1:1 hydrochloric acid (HCl)
TAL Volatiles				
BTEX		14 days	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace	1:1 hydrochloric acid (HCl)
GRO				
EPH		14 days	One 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl)

Store on ice 4°C.
Contact the TDH Environmental Laboratory for collection instruction for other types of analyses.

APPENDIX C

Monitoring to Support TMDL Development

A. MONITORING TO SUPPORT TMDL DEVELOPMENT

Tennessee Division of Water Pollution Control
Watershed Management Section

1. Metals

Flow

Hardness (as $CaCO_3$)
TSS
TOC
Metals (Total)
Metals (Dissolved)-Cd, Cu, Pb, Ni, Ag, Zn (if necessary)
pH
Conductivity

Minimum number of data points at each site must be twelve (12) or more. Some data points should be obtained at low-flow conditions.

2. Organic Enrichment/DO

Flow

Velocity (Dye Study)
DO
$CBOD_5$ & CBODu
Temperature (Water)
NH_3
NO_2/NO_3
Total phosphorus (TP)
Total Kjeldahl Nitrogen (TKN)
pH
Channel Cross-section (geometry, width, depth)
Notes as to time, last precipitation, presence of algae, weather conditions, canopy, stream characteristics, location of point source discharges, tributaries (flow), etc.

Helpful:

Temperature (Air)
Diurnal DO (3 day)
Chlorophyll-A
Ortho-P
Organic N
CBOD Decay Rate
Reaeration Rate
SOD

Sampling should be conducted in several locations in the area of interest.

In the QUAL2E model, a reach is a section of stream with uniform hydraulic, geometric, and biochemical properties. Ideally, sampling should be conducted in a location representative of the reach.

One sampling station should be upstream of the area of interest to provide background data.

At least one sampling event should be as close as possible to summer, low-flow conditions.

Always provide location of sampling

Always include units

3. Nutrients

Flow

NH_3
NO_2/NO_3
Total phosphorus (TP)
Total Kjeldahl Nitrogen (TKN)
TSS
Turbidity
Temperature
Conductivity
DO
pH
Weather conditions (sample day plus previous 2 days)

One-Year Program:

Minimum of 12 samples total

Minimum of 4 high-flow samples

Monthly samples (12) with at least one high-flow sample per quarter (4)

Minimum of 3 weeks between samples (unless total sample number increased; e.g., storm characterization, baseflow and high-flow samples collected in a given month, etc.)

Note: For remote watersheds, establish a fixed sampling day each month (e.g., first Tuesday of each month) for the purpose of collection of representative data (covering a range of flow conditions)

Two-Year Program:

Follow one-year program (above) during first year

Second year:

Minimum of 6 samples total

Minimum of 2 high-flow samples

Monthly samples (6) during wet (January-March) and dry (August-October) seasons with at least one high-flow sample collected during each period (2)

Minimum of 3 weeks between samples (unless total sample number increased; e.g., storm characterization, baseflow and high-flow samples collected in a given month, etc.)

4. Pathogens

Flow

Fecal coliform
Fecal strep
E. coli
TSS
Turbidity
DO
pH
Temperature
Conductivity
Weather conditions (sample day plus previous 2 days)

One-Year Program:

Minimum of 12 samples total

Minimum of 4 high-flow samples

Monthly samples (12) with at least one high-flow sample per quarter (4)

Minimum of 3 weeks between samples (unless total sample number increased; e.g., storm characterization, baseflow and high-flow samples collected in a given month, etc.)

Note: For remote watersheds, establish a fixed sampling day each month (e.g., first Tuesday of each month) for the purpose of collection of representative data (covering a range of flow conditions)

Two-Year Program:

Follow one-year program (above) during first year

Second year:

Minimum of 6 samples total

Minimum of 2 high-flow samples

Monthly samples (6) during wet (January-March) and dry (August-October) seasons with at least one high-flow sample collected during each period (2)

Minimum of 3 weeks between samples (unless total sample number increased; e.g., storm characterization, baseflow and high-flow samples collected in a given month, etc.)

Guidelines for collection of high-flow samples:

During wet season (January to March): ≥ 0.25 inches of rain in last 24 hours prior to sample collection

During dry season (August to October): ≥ 0.5 inches of rain in last 24 hours prior to sample collection

Protocol for Collection of Flow

General guidelines:

- temporary high-water marks can be "recorded" on stationary objects (bridges, trees, sign posts, etc.) with an indelible marker, knife, nails, etc. for later retrieval; stream depths corresponding to these high-water marks can be accurately determined with surveying equipment at a later time (stream geometry can also be surveyed later) – use a "floating chip" to measure velocity with each water level "measurement"

- where measurements cannot be made (e.g., high-flow/storm), estimates should be made based on channel geometry, depth of flow, and velocity (e.g., floating chip)

- install a staff gage prior to storm event sampling (must be stationary) and read/record stage for each sample collected (also need stream channel geometry [width, depth, channel cross-sectional shape/area] and velocity measurements/estimates for each sample collected) – manual measurement at low flows if possible

- for sampling locations at or near USGS stage recorders, record the staff gage reading for each sample collected (the station rating can then be used to calculate flow) – don't assume that the USGS recorder is working properly or, if it is, that it is recording water level data at the appropriate frequency – measure (or estimate) and record distance upstream or downstream from the USGS gage, note tributaries entering stream/river between the USGS gage and the sampling location (if possible, measure or estimate flow in tributary to add or subtract), significant changes in character of stream/river, etc.

- when measuring velocity in a stream, choose a straight reach of uniform cross-section and slope with a minimum number of surface waves, eddies, cross-currents, and still pools – select cross-sections at the beginning, midpoint, and end of the reach, each being far enough apart so the travel time from one cross-section to another can be accurately measured

Additional method:

- install a temporary stage data recorder prior to storm event sampling – calibrate (verify) with staff gage readings (measurements) for each sample collected and make manual flow measurements where/when possible

Flow measurement/estimation techniques:

Level I:

- Current meter (cup or propeller type): two-point method or six-tenths-depth method

- Bucket gaging (timed volumetric measurement) – generally practical only for low flows on small streams (1st or 2nd order) where there is a drop in the stream

  Floating chip velocity measurement (area determined by geometry; Q = V * C * A, where C = coefficient to correct for mean velocity)

- Installation of temporary flumes – practical only on small streams (1st or 2nd order) with low to moderate flows (< 10 cfs)

- Comparison to known field-rated cross-section (e.g., USGS station) in close proximity (preferably on same stream)

- Dye slug for time of travel (velocity) measurement

Level II:

- Dye tracers (dilution for "direct" flow measurement) – continuous, steady state release of known concentration of dye solution at known release (flow) rate – measure concentration at downstream point in stream at which complete mixing has occurred:

  $$Q*C_0 + q*C_1 = (Q + q)*C_2$$

  and $$Q = q*(C_1 – C_2)/(C_2 – C_0)$$

  where q = injection rate

  C_1 = tracer concentration

  C_0 = initial in-stream concentration

  C_2 = final concentration

- Slope-area method – applicable where a straight reach with uniform cross-section, slope, and roughness characteristics is long enough to accurately measure change in elevation (i.e., slope): $Q = (1.49/n)* A*R^{2/3} *S^{1/2}$

  where n = Manning's roughness coefficient (unitless)

  A = flow area = f(W, D) [ft^2]

  W = width [ft]

  D = depth [ft]

  R = hydraulic radius = A/P [ft]

  P = wetted perimeter (simple assumption is trapezoidal channel cross-section) (ft)

  S = channel slope [ft/ft]

Estimate n; measure W, D, S; calculate A, P, R; and calculate Q [ft^3/s]

Protocol for Storm Event Characterization

Level I:

Collect a minimum of 3 samples during each storm event with the objective of collecting at least one sample during each phase of the storm hydrograph: rising limb, near the peak, and on the recession

Level II:

Collect 6-10 samples during each storm with the objective of fully representing the storm hydrograph: 2-3 samples on the rising limb, 1-2 at or near the peak, and 3-5 on the recession of the hydrograph

Characterize storms during seasonal wet (January-March) and dry (August-October) periods (at least one storm each) in order to differentiate seasonal characteristics

> Wet season storm events tend to be longer duration (days) and may require more samples, on average, than dry season storm events with shorter duration (hours)

General storm event characterization guidelines:

During wet season (January to March): ≥ 0.25 inches of rain in last 24 hours prior to sample collection

During dry season (August to October): ≥0.5 inches of rain in last 24 hours prior to sample collection

> **Note**: Many factors (antecedent moisture conditions, drainage area, rainfall intensity, land use, soil permeability, ground cover, etc.) can affect the stormflow runoff potential and dynamics in a watershed. The above are guidelines only; best professional judgment should be used.

Pursuant to the State of Tennessee's policy of non-discrimination, the Tennessee Department of Environment and Conservation does not discriminate on the basis of race, sex, religion, color, national or ethnic origin, age, disability, or military service in its policies, or in the admission or access to, or treatment or employment in its programs, services or activities. Equal Employment Opportunity/Affirmative Action inquiries or complaints should be directed to the EEO/AA Coordinator, Office of General Counsel, 401 Church Street, 20th Floor L & C Tower, Nashville, TN 37243, 1-888-867-7455. ADA inquiries or complaints should be directed to the ADA Coordinator, Human Resources Division, 401 Church Street, 12th Floor L & C Tower, Nashville, TN 37243, 1-866-253-5827. Hearing impaired callers may use the Tennessee Relay Service (1-800-848-0298).

To reach your local
ENVIRONMENTAL ASSISTANCE CENTER
Call 1-888-891-8332 OR 1-888-891-TDEC

Tennessee Department of Environment and Conservation, Authorization No. 327___, ___ copies. This public document was promulgated at a cost of $___ per copy. _____ 2004.